LAKE ENHANCEMENT PROGRAM
FEASIBILITY STUDY
FOR
BEAVER CREEK RESERVOIR

Prepared for:

THE CITY OF JASPER
MUNICIPAL WATER UTILITY
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EXECUTIVE SUMMARY

Beaver Creek Reservoir, located in Dubois County, is a man-made, secondary potable water supply reservoir for the City of Jasper. It has a surface area of 157.3 acres, a mean depth of 12.9 feet, a maximum depth of 29.0 feet, and a 2369.5 acre watershed. The reservoir is situated on Beaver Creek, a tributary of the Patoka River which is the city's primary potable water supply. The reservoir was constructed in 1955, and is located 5 miles east of Jasper on State Road 164. The watershed is predominantly forest lands (63 percent) with agricultural lands secondary in acreage (29 percent). There is residential/recreational development along most of the lake shore in cottages, trailers and sheds most of which have outhouses (58 percent). Problems concerning aquatic vegetation and siltation have been reported since the late 1960s.

The objectives of this feasibility study were to assess the current characteristics of the lake and its watershed; identify the eutrophication problems, their sources and relative contributions; and develop restoration alternatives, recommending the most practicable and potentially successful alternative.

Currently Beaver Creek Reservoir is undergoing the consequences of sediment and nutrient loading from non-point source pollution. The evidence is the nutrient and bacterial concentrations in storm runoff, the populations of blue-green and filamentous algae, the extent of submergent and emergent aquatic vegetation, and the decrease of lake surface area due to sedimentation at the lake inlets.

The primary source of the sediment and nutrient loading is highly erodible soils within the watershed. Agricultural cropland, tillage methods, cropping practices, and fertilization methods expedite the rate of soil loss. Secondary sources are hog lots and grazed pastures contributing manure and suspended solids to storm runoff. Stream bank erosion and gully erosion are also significant sources of sedimentation. Malfunctioning septic tanks and holding tanks are sources of bacteria to the lake in specific areas.

The restoration of Beaver Creek Reservoir must primarily concentrate on the land application of the T by 2000 program, developing and implementing Best Management Practices (BMPs), specifically on agricultural lands and along the lake shore and its tributaries. Specific practices would include conservation tillage, contour farming, contour strip-cropping, animal waste management, livestock exclusion and streamside management zones. Further reduction in sediment and nutrient loading would be accomplished by the construction of sediment ponds and wetland systems at principle inlets. Aquatic vegetation would be controlled by a combination of lake drawdown, harvesting and herbicide application, with the drawdown primarily aiding in the consolidation of lake sediments and sealing of sediment nutrients.

A final recommendation involves a waste management program for the monitoring of septic systems, holding tanks and outhouses as a part of an overall Lake Management Plan. A foundation for this plan is already established in City regulations. The Beaver Lake Improvement Association, City of Jasper officials, local landowners, and other concerned users of the reservoir should be made aware of the significance of the problems occurring at Beaver Creek Reservoir and the necessary actions required to restore the reservoir to an improved condition. These significant problems and the resulting necessary actions to restore the reservoir would be a part of the Lake Management Plan. A plan would be developed providing for the long-term, consistent management and continued usage of Beaver Creek Reservoir as a water-supply and recreational reservoir.

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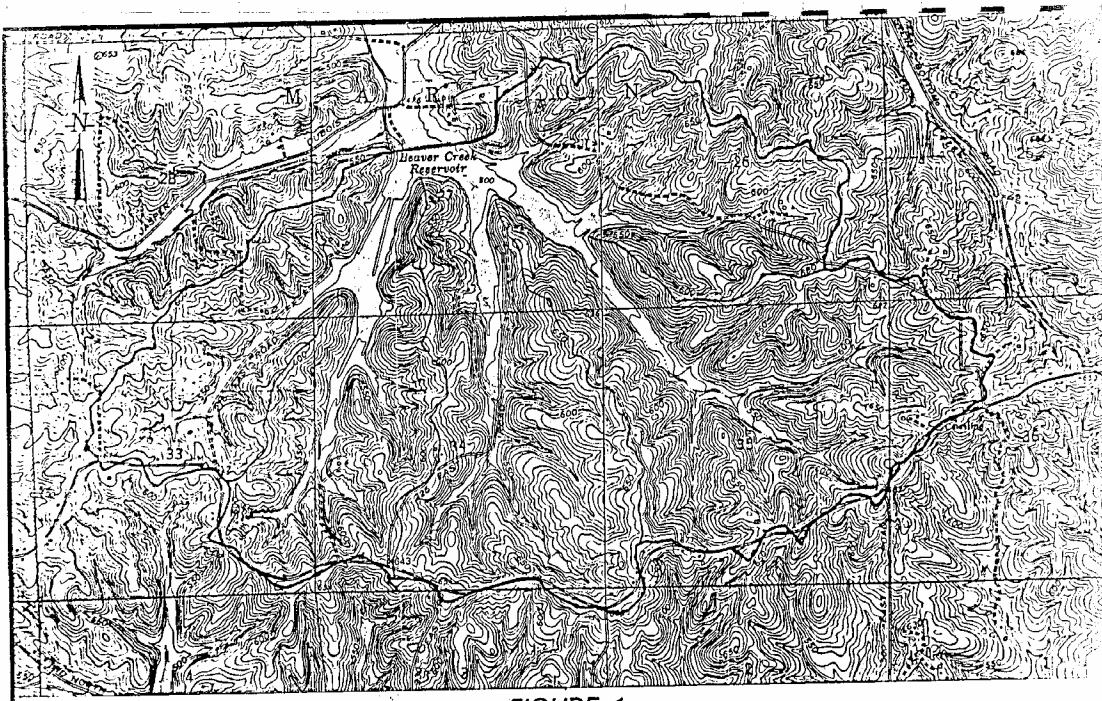
SECTION 1. INTRODUCTION

1.1 Beaver Creek Reservoir and Watershed

Located in Dubois County, Beaver Creek Reservoir is the secondary potable water supply for the City of Jasper. The reservoir is located approximately 5 miles east of Jasper on State Road 164 and 4 miles southwest of Dubois (Figure 1). The reservoir and its watershed lie within Sections 26, 27, 28, 33, 34 and 35, Township 1 South, Range 4 West, on the U.S.G.S. Dubois 7.5-Minute Quadrangle Map dated 1969.

Construction of the reservoir began in 1955, with the lake opened to the public in 1958 as a water-supply and recreational facility. It has a current surface area of 157.3 acres, a mean depth of 12.9 feet, a maximum depth of 29.0 feet and a 2369.5 acre watershed. The reservoir is owned by the City of Jasper and is operated by the Municipal Water Utility with the public boat launching facilities and recreational lots operated by the Jasper Park and Recreation Board (Figure 2). Numerous summer cottages, trailers, sheds and temporary shelters occupy the lake shore except for the western edge which is primarily agricultural with a limited amount of permanent farmsteads. The watershed is primarily forested and agricultural with much of the drainage entering the lake through seven unnamed tributaries. The lake discharges into Beaver Creek just upstream of the confluence with the Patoka River. It has an earthen dam of silty clay with a rock-cut channel spillway located on the west edge of the dam.

The lake has been characterized as a warm, shallow and fertile lake with a bottom of gravel, sand, muck and clay (Fish Management Report, 1987). Past aerial photography and fish management reports have characterized the watershed as hardwood forest and agricultural land. Residential development had previously been limited to temporary, summer residences for vacation and recreational purposes. Recently, houses have been or are planned to be constructed for permanent residence on the lake shore, though lots are leased from 3 private individuals and the City of Jasper on an annual basis.



WATERSHED BOUNDARY

SCALE
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FIGURE 1.
BEAVER CREEK RESERVOIR

LAKE SURFACE AREA	157.3 AC
WATERSHED AREA	2369.5 AC
TOTAL ACREAGE	2526.8 AC

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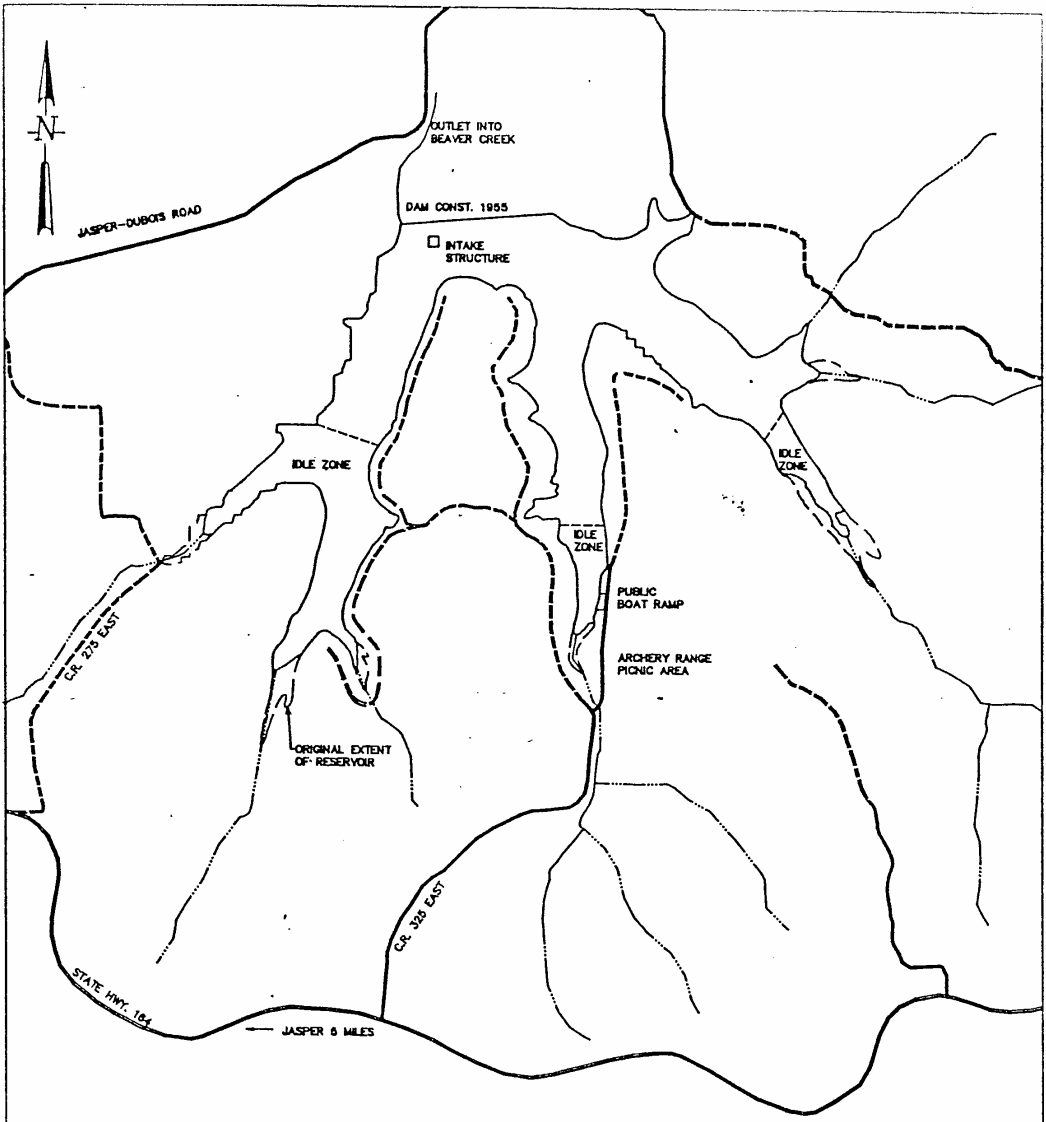

FIGURE 2.
HISTORICAL FEATURES OF
BEAVER CREEK RESERVOIR

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1.2 Water Quality Problems

The noted problem at Beaver Creek Reservoir has been an ongoing aquatic macrophyte overpopulation. As early as 1964, the fingers of the lake have been treated with Aquathol to control weeds, namely naiads, (Najas flexilis) (Fish Management Report, 1966). The 1967 Fish Management Report recommended an aquatic weed control program to not only facilitate lake access, but also to reduce the excessive cover contributing to a potentially stunted bluegill population. The lake has consequently been treated numerous times over the last two decades. The lake was last treated in June of 1988. Due to conflicts between weed control treatments and recreational use, the lake was not treated in 1989. During the summer and fall of 1989, not only were aquatic macrophytes at excessive amounts, but floating mats of blue-green and filamentous algae were common throughout the lake. It has also been noted by residents and fishermen that sedimentation of the upper fingers of the lake has dramatically reduced the accessibility into coves of the lake in recent years. The Municipal Water Utility and Dubois County Health Department also have concerns over the long-term water quality of the lake in regards to the recreational development along the lake shore.

1.3 Feasibility Study Objectives

The objectives of this study were to assess the current characteristics of the lake and the surrounding watershed; to identify historical and existing eutrophication problems, their sources and relative contributions; to develop lake restoration alternatives; and to recommend the most practicable and potentially successful alternative. This study included historical lake data and watershed land usage (Section 2.1), field surveys and sampling programs (Section 2.2), analysis of data (Section 3), restoration alternatives (Section 4), the preferred alternative with recommendations (Section 5), along with references.

SECTION 2. PRESENTATION OF DATA

2.1 Historical Data

The Indiana Department of Natural Resources, Division of Fish and Wildlife conducted fisheries surveys in 1962, 1966, 1968, 1977 and 1987 at Beaver Creek Reservoir (Table 1).

TABLE 1. BEAVER CREEK RESERVOIR

HISTORICAL WATER QUALITY PARAMETERS

SOURCE	DATE	SECCHI DEPTH	SURFACE pH	TEMP. @5 FT	D.O. @5 FT	SAT. @5 FT
Donan Eng.	9 Aug 89	7.7 ft	8.3	25.9° C	10.1 ppm	126%
Div. F & W	18-21 July 77	6.9 ft	8.5	31.5° C	8.0 ppm	108%
Div. F & W	1-2 Aug 68	11.2 ft	7.5	27.5° C	7.6 ppm	103%
Div. F & W	27 July 66	9.5 ft	7.5	27.4° C	7.8 ppm	100%

D.O. = Dissolved Oxygen
SAT. = D.O. % Saturation

Fish Management Reports have consistently commented on the extensive populations of American pondweed (Potamogeton nodosis), naiads (Najas minor, Najas flexilis), cattail (Typha spp.) and bulrush (Scirpus spp.). It had been recommended as early as 1966 that weed control was necessary to limit these and other aquatic macrophytes present in specific areas of the lake. Naiads had been recorded to cover 20 to 25 percent of the lake bottom to a depth of 10 feet. After several years of aquatic herbicide applications, it was reported that aquatic weeds were not affecting the fish or fishing opportunities (Fish Management Report, 1987). Floating colonies of filamentous algae were recorded in 1977.

The lake has provided excellent fishing opportunities for bluegill, as well as catch-and-release fishing for largemouth bass. Opportunities are good for catching channel catfish, redear sunfish and black crappie, as well as longear and green sunfish, warmouth and brown bullheads. Largemouth bass are abundant in the 8 to 12-inch size class, with a 14-inch limit enforced on the lake.

The U.S. Army Corps of Engineers published Phase I (U.S. Corps of Engineers, 1980) and Phase II (U.S. Corps of Engineers, 1982) inspections of the dam at Beaver Creek Reservoir as a part of their National Program of Inspection of Non-Federal Dams. The Phase I report described the lake as having a normal pool elevation of 498.9 feet, with the top of the dam at 508.0 feet. The storage capacity was reported at 2550 acre-feet at normal pool, with a surface area of 173 acres and a watershed of 3.95 square miles. The drawdown facility for the lake is an 18-inch, cast iron pipe with an 18-inch sluice gate in the intake tower. The intake tower was at a tilt thought to be due to settlement. The principal spillway is a rock-cut channel. There is no emergency spillway. The Phase II report recommended maintenance programs and remedial actions for the dam and intake structure.

Historically, the watershed land use has not dramatically changed since the 1950s, except for the pronounced residential development along State Road 164 and the pronounced recreational summer cottage development along the lake shore pronounced since the early 1960s. Selective timber harvesting has been common in the forest areas throughout the lake watershed. Modern agricultural practices have for the most part been adopted though limited lands are in set-aside programs or the Conservation Reserve Program (CRP).

The U.S.D.A. Soil Conservation Service has conducted extensive soils mapping throughout the lake watershed including the determination of highly erodible soils. As shown on the Beaver Creek Reservoir Soils Map (Appendix), 97 percent of the lake watershed is composed of highly erodible soils. Only the Bonnie, Cuba, Steff and Stendal soils occurring along the stream channels are not classified as highly erodible.

Based on the records of the Indiana Department of Natural Resources, Division of Nature Preserves, there are currently no known state or federally listed endangered, threatened or rare species of plants or animals present. There are no known significant natural areas or features, nor dedicated nature preserves within the Beaver Creek Reservoir watershed. There is a Classified Wildlife Area managed for wildlife benefit as approved by the Division of Fish and Wildlife on the western section of the watershed on private property.

Throughout the historical records and from personal observations on the part of staff with the Municipal Utility, Park and Recreation Board, and County Health Department, Beaver Creek Reservoir has consistently had problems with aquatic macrophyte populations and has recently developed algal problems. There has also been concern over the extensive recreational development in summer cottages along the lake shore, and the marked sediment accumulation in the coves and upper fingers of the lake while having a watershed that is almost entirely composed of highly erodible soils.

2.2 Field Surveys

The initial field survey of Beaver Creek Reservoir was conducted on August 9, 1989, by Donan Engineering Co., Inc. staff to collect samples providing for the analysis of lake water quality, sediment composition and quantity, plankton species and populations, and aquatic macrophyte identification. The equipment used during the lake reconnaissance consisted of a Hydrolab Surveyor II, a Martek transmissometer, a Secchi disk, an Eagle depth finder, a Kahlisico column sampler and a Monark boat.

In-situ water quality parameters were monitored at the lake pool station (BC-06, Figure 3). In-situ profile measurements of temperature, dissolved oxygen, pH, turbidity, conductivity and light transmissivity were made at five-foot intervals to immediately above the lake bottom. Secchi disk depth was recorded, and plankton samples were collected. For a listing of field and laboratory parameters, refer to Table 2.

Sediment samples and volume data were collected at stations BC-1, BC-2, BC-3 and BC-4 reflecting major inlet points (Figure 3). The three foot deep and four inch diameter samples were collected using a mud auger. The samples were composited and analyzed for metals, pesticides, herbicides and nutrient concentrations.

A visual aquatic plant survey of Beaver Creek Reservoir was conducted with photographic documentation (Appendix). Algal tows were done from five feet to the surface, a second tow of five feet through the thermocline, and a third tow near the lake bottom. Predominant plankton species were identified and analyzed for population density.

A field survey was conducted on September 1, 1989, during a 1.1-inch/5-hour storm event to collect the lake influent samples and flow data to monitor non-point source loading. Another field survey was conducted on October 2, 1989 to collect fecal bacterial samples during low-flow conditions. For the listing of the methods and references refer to Table 3. Fecal bacteria samples were taken at lake stations BC-1 through BC-7. Stations BC-1 through BC-5 reflect influent points monitored during the storm event. Station BC-6 is the lake pool station, with station BC-7 located near the center of the lake adjacent to one of the recreationally developed areas of the lake shore (Figure 3). Samples were analyzed for fecal coliform and fecal streptococcus counts.

Watershed land use information was collected through several means. An aerial photograph of the lake and its watershed was taken on September 4, 1989. The 1978 U.S.D.A. Soil Conservation Services's Soil Survey of Dubois County, Indiana was used to determine soil types and runoff characteristics as well as to create the Beaver Creek Reservoir Soils Map. Field verifications were conducted in late September and in October to collect information on land uses, cropping practices and recreational structures. Contacts were made in the attempt to acquire information on livestock populations and agricultural management techniques as well as a

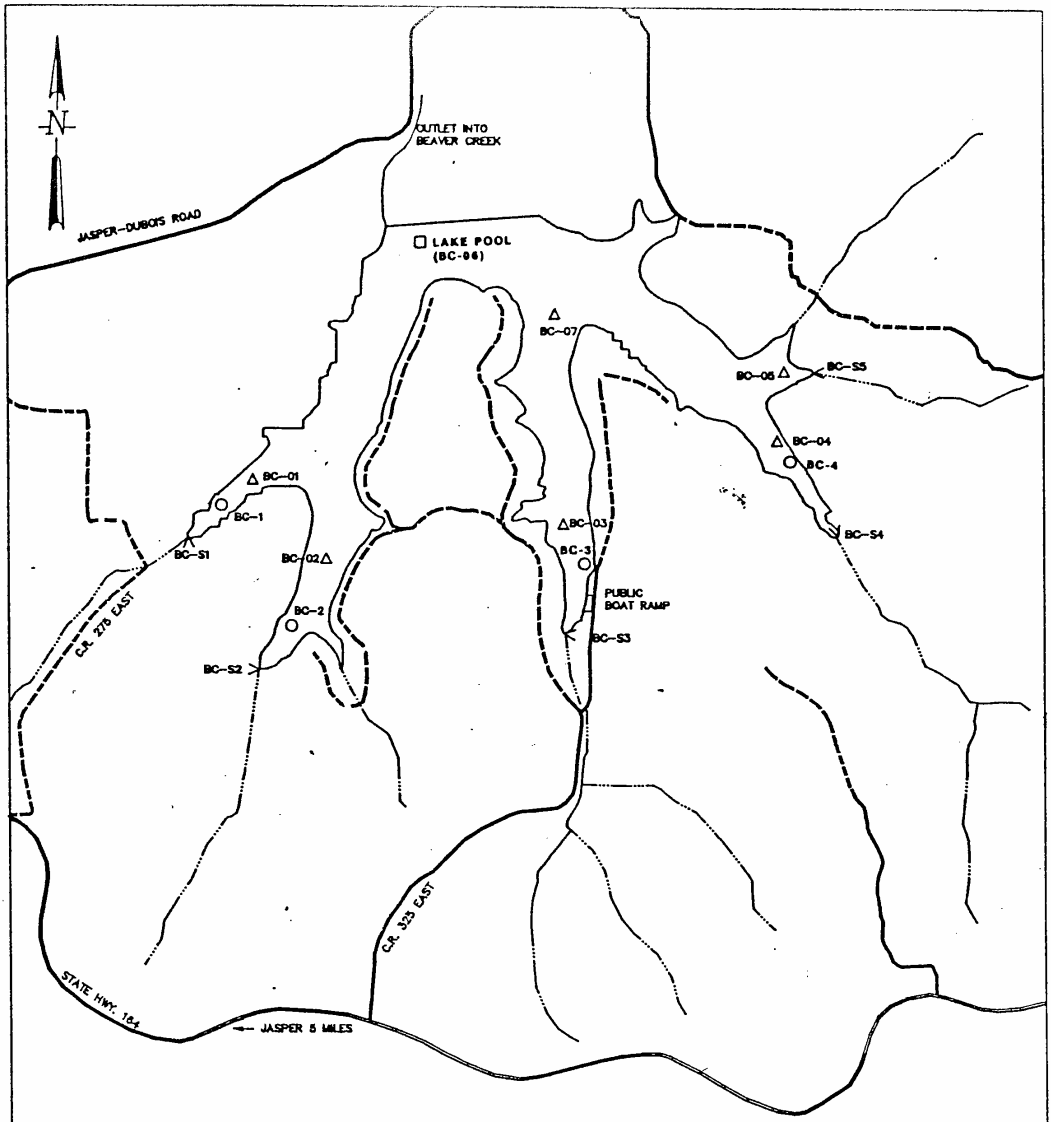

FIGURE 3.
MONITORING POINTS ON BEAVER CREEK RESERVOIR

MONITORING POINTS

- □ LAKE POOL
- △ LOW FLOW
- V STORM EVENT
- ○ SEDIMENT

SCALE

0 1320

FEET

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TABLE 2.

FIELD AND LABORATORY PARAMETER LIST
BEAVER CREEK RESERVOIR

LAKE POOL

Field:

- pH
- Temperature
- Secchi Disk Reading
- Turbidimeter Reading
- Dissolved Oxygen
- Specific Conductance
- Light Transmission
- Plankton

Laboratory:

- Total Suspended Solids
- Nutrients:
  - Total Phosphorus
  - Dissolved Phosphorus
  - TKN
  - Nitrate
  - Ammonia
- Bacteria:
  - Fecal Coliform
  - Fecal Streptococcus

LAKE INFLUENT

Field:

- pH
- Temperature
- Discharge

Laboratory:

- Dissolved Oxygen
- Total Suspended Solids
- Nutrients:
  - Total Phosphorus
  - Dissolved Phosphorus
  - TKN
  - Nitrate
  - Ammonia
- Bacteria:
  - Fecal Coliform
  - Fecal Streptococcus

SEDIMENT CORES

Laboratory:

- Total Solids
- EP Toxicity Test: Metals
  Herbicides and Pesticides
- Nutrients: Total Phosphorus
  Dissolved Phosphorus
  TKN
  Nitrate
  Ammonia

TABLE 3.

CHEMICAL PARAMETERS AND ANALYTICAL METHODS

PARAMETER	INSTRUMENT OR METHOD	REFERENCE SECTION
Total Phosphorus	Colorimetric	424 C III
Soluble Phosphorus	Colorimetric	424 C III
Nitrate	Ion Chromatography	429
Ammonia	Specific Ion Electrode	417 E
Total Suspended Solids	Gravimetric	209 C
Fecal Coliform	Incubation, Visual Count	909 A
Fecal Streptococcus	Incubation, Visual Count	910

Reference Source: Standard Methods 16th Edition

severely eroded area on the northeastern edge of the watershed. A water/sewage questionnaire was sent out by the City of Jasper in conjunction with the Dubois County Health Department to determine sewage management procedures, water consumption and source, and length of occupation of the vacation cottages around the lake. All pertinent information was incorporated into the Beaver Creek Reservoir Watershed Map, with water/sewage survey results included in the Appendix.

3.1 Eutrophication Index

The Indiana Lake Classification System and Management Plan (IDEM, 1986) provides a eutrophication index system developed by Harold BonHomme of the Indiana State Board of Health assigning points for various lake trophic parameters with the total value based on a scale of 0 to 75. The index utilizes the trophic parameter information gathered during the field surveys, specifically the in-situ lake pool water data and the plankton data.

In-situ water quality results are presented as Table 4 and Figures 4 and 5. These data illustrate that Beaver Creek Reservoir was thermally stratified with the thermocline at approximately 13.5 feet. Dissolved oxygen concentrations were above saturation at moderate levels to the thermocline, and were present at concentrations greater than 1.0 ppm throughout the water column. Turbidity was at moderate readings, except for increased readings at the air-water interface. Conductivity progressively increased with depth. Light transmissivity was at moderate levels, dramatically decreasing below the thermocline.

The composite lake water quality analysis is given in Table 5. These data are water column averages derived from samples taken at 3 different depths. As shown, the concentration of ammonia was significantly high. The total Kjeldahl nitrogen (TKN) concentration was excessively high at 23.4 mg/L, and will be disregarded as an anomaly. Phosphorus concentrations were found to be moderate for both dissolved and total phosphorus.

TABLE 4.

BEAVER CREEK RESERVOIR IN-SITU WATER QUALITY RESULTS

AUGUST 9, 1989.

SAMPLE ID	TIME	DEPTH FEET	pH	TEMP °C	D.O. mg/L	SAT.	L.T.	TURBID. (JTU)	CONDUCT. (umhos/cm)
BC-06 (Lake Pool)	1000	0	8.2	25.9	10.1	126%	64%	500	111
		5	8.3	25.9	10.1	126%	59%	290	111
		10	8.3	25.8	9.7	121%	57%	290	111
		12.5	8.2	25.7	9.1	113%	57%	290	111
		15	6.7	21.7	4.1	48%	53%	300	120
		17.5	6.5	17.8	1.0	11%	2%	270	154
		20	6.5	15.3	1.3	13%	1%	30	185
		25	6.5	13.1	1.2	12%	1%	20	213

D.O. = Dissolved Oxygen
SAT. = D.O. % Saturation
L.T. = Light Transmissivity

TABLE 5. BEAVER CREEK RESERVOIR WATER QUALITY ANALYSIS

DATE	TIME	NH_3-N mg/L	NO_3-N mg/L	TKN mg/L	OP mg/L	TP mg/L	TSS mg/L
09 Aug.89	1100	0.90	<0.05	23.4	0.04	0.12	20

NH_3-N = Ammonia as Nitrogen
NO_3-N = Nitrate as Nitrogen
TKN = Total Kjeldahl Nitrogen
OP = Dissolved Phosphorus
TP = Total Phosphorus
TSS = Total Suspended Solids

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FIGURE 4.

Selected Water Quality Parameters vs. Sampling Depth at Beaver Creek Reservoir BC-1

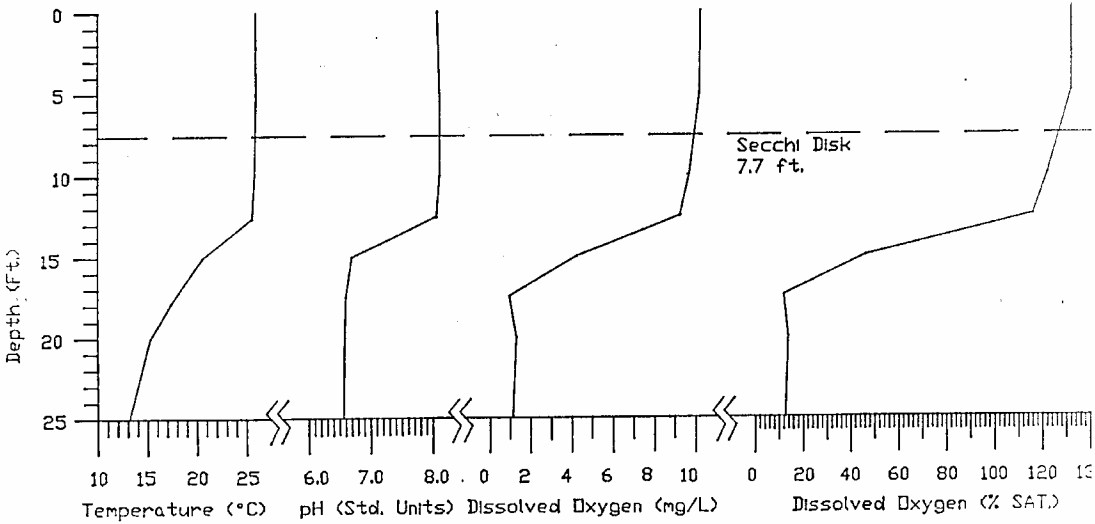

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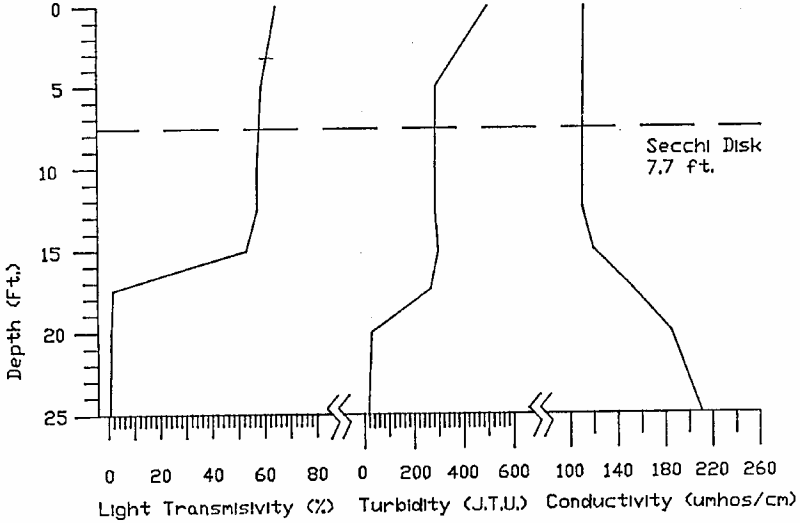
FIGURE 5.

Selected Water Quality Parameters vs. Sampling Depth at Beaver Creek Reservoir BC-1



The plankton analysis (Table 6) points to significant concentrations of algae in the lake pool sample. Flagellate algae (Chlamydomonas and Platydorina) were predominant at the 5.0 feet to surface tow exhibiting concentrations of 10,000 per ml. Filamentous and non-filamentous green algae (Ulothrix and Ankistrodesmus), as well as blue-green algae (Nostoc and Anabaena) were present at the five feet thermocline tow at concentrations of 40,000 per ml. Floating masses of algae were keyed to blue-green (Oscillatoria) and filamentous green algae (Ulothrix). Three of the algal species present are noted as common nuisance algae attributing to algal blooms, odor production and other problems: Anabaena, Chlamydomonas and Oscillatoria (Palmer, 1964).

TABLE 6a. BEAVER CREEK RESERVOIR PLANKTON ANALYSIS
IN ORDER OF PREDOMINANCE
AUGUST 9, 1989

SAMPLE DEPTH	ALGAE	TOTAL NUMBER Per ML
5.0 ft. to surface	Chlamydomonas Anabaena Platydorina Ulothrix	10,000/ml
Thermocline	Ulothrix Ankistrodesmus Nostoc Anabaena Eudorina	40,000/ml

This collective information of in-situ data, lake pool data and plankton populations forms the data base for the calculation of the Eutrophication Index. The assessment of Beaver Creek Reservoir is a Eutrophication Index Value between 28 and 31 as shown in Table 7a.

TABLE 7a. ISBH LAKE EUTROPHICATION INDEX
BEAVER CREEK RESERVOIR - AUGUST 9, 1989

Parameter and Range	Range Observed	Eutrophy Points
I. Total Phosphorus (ppm)		
A. At least 0.03		1
B. 0.04 to 0.05		2
C. 0.06 to 0.19	0.12	>3<
D. 0.2 to 0.99		4
E. 1.0 or more		5
II. Soluble Phosphorus (ppm)		
A. At least 0.03		1
B. 0.04 to 0.05	0.04	>2<
C. 0.06 to 0.19		3
D. 0.2 to 0.99		4
E. 1.0 or more		5
III. Organic Nitrogen (ppm)		
A. At least 0.5	--- Anomaly ---	>1<
B. 0.6 to 0.8	Assumed Range	2
C. 0.9 to 1.9	of 0.5 to 2.0	3
D. 2.0 or more		>4<
IV. Nitrate (ppm)		
A. At least 0.3	<0.05	1
B. 0.4 to 0.8		2
C. 0.9 to 1.9		3
D. 2.0 or more		4
V. Ammonia (ppm)		
A. At least 0.3		1
B. 0.4 to 0.5		2
C. 0.6 to 0.9	0.9	>3<
D. 1.0 or more		4
VI. Dissolved Oxygen (Percent Saturation at 5 ft. from surface)		
A. 114% or less		0
B. 115% to 119%		1
C. 120% to 129%	126%	>2<
D. 130% to 149%		3
E. 150% or more		4
VII. Dissolved Oxygen (Percent of water column with D.O. $\geq$ 0.1 ppm)		
A. 28% or less		4
B. 29% to 49%		3
C. 50% to 65%		2
D. 66% to 75%		1
E. 76% to 100%	100%	>0<

TABLE 7a. ISBH LAKE EUTROPHICATION INDEX (CON'T.)
BEAVER CREEK RESERVOIR - AUGUST 9, 1989

Parameter and Range	Range Observed	Eutrophy Points
VIII. Light Penetration		
Secchi Disc		
A. Five feet or under	7.7 ft.	6
IX. Light Transmission		
(Percent at 3 ft.)		
A. 0 to 30%		4
B. 31% to 50%		3
C. 51% to 70%	61%	>2<
D. 71% and up		0
X. Total Plankton per ml:		
(Vertical tow from 5 ft. to surface)		
A. Less than 500 ml		0
B. 500 to 1,000/ml		1
C. 1,000 to 2,000/ml		2
D. 2,000 to 3,000/ml		3
E. 3,000 to 6,000/ml		4
F. 6,000 to 10,000/ml	10,000	>5<
G. More than 10,000/ml		10
H. Blue-green dominance		5 additional points
(Vertical tow of 5 ft. through thermocline)		
A. Less than 1,000/ml		0
B. 1,000 to 2,000/ml		1
C. 2,000 to 5,000/ml		2
D. 5,000 to 10,000/ml		3
E. 10,000 to 20,000/ml		4
F. 20,000 to 30,000/ml		5
G. 30,000 or more	40,000	>10<
H. Blue-green dominance		5 additional points
I. Populations of 100,000 or more		5 additional points

EUTROPHICATION INDEX 28 to 31

Donan Engineering wanted to verify the unusually high plankton data that was collected on August 9, 1989 and obtain separate epilimnetic and hypolimnetic nutrient concentrations as opposed to one composite number. Therefore, Beaver Creek was resampled for those parameters that were necessary to recalculate the Eutrophication Index at Donan Engineering's expense on August 24, 1990. The plankton were collected using a 63 micron net mesh closing net. The samples were quantified using a 1-ml Sedgwick-Rafter counting cell. All chemical, physical, and biological data sheets can be referenced in the Appendix. The new data yields the following plankton information:

TABLE 6b. BEAVER CREEK RESERVOIR PLANKTON ANALYSIS
AUGUST 24, 1990

5.0 FOOT TO SURFACE DEPTH

ALGAE	TOTAL # PER LITER
Cyanophyta	
Anabaena	3,698
Microcystis	1,557
Oscillatoria	778
Coelosphaerium	1,557
Aphanizomenon	389
Chrysophyta - Bacillasiophyceae	
Synedra	195
Pyrrophyta	
Ceratium	195
Peridinium	584
Rotifera	
Polyarthra	1,946
Total =	10,899

5.0 FOOT THROUGH THERMOCLINE 12 FOOT TO 7 FOOT

ALGAE	TOTAL # PER LITER
Cyanophyta	
Anabaena	2,534
Microcystis	362
Aphanizomenon	4,163
Rotifera	
Chromogaster	181
Total =	7,240

The following eutrophication index is obtained when using the 1990 data.

TABLE 7b. ISBH LAKE EUTROPHICATION INDEX
BEAVER CREEK RESERVOIR - AUGUST 24, 1990

Parameter and Range		Range Observed	Eutrophy Points
I.	Total Phosphorus (ppm)		
	A. At least 0.03		1
	B. 0.04 to 0.05		2
	C. 0.06 to 0.19	0.135	>3<
	D. 0.2 to 0.99		4
	E. 1.0 or more		5
II.	Soluble Phosphorus (ppm)		
	A. At least 0.03		1
	B. 0.04 to 0.05	0.053	>2<
	C. 0.06 to 0.19		3
	D. 0.2 to 0.99		4
	E. 1.0 or more		5
III.	Organic Nitrogen (ppm)		
	A. At least 0.5	0.425	1
	B. 0.6 to 0.8		2
	C. 0.9 to 1.9		3
	D. 2.0 or more		4
IV.	Nitrate (ppm)		
	A. At least 0.3	<0.1	1
	B. 0.4 to 0.8		2
	C. 0.9 to 1.9		3
	D. 2.0 or more		4
V.	Ammonia (ppm)		
	A. At least 0.3		1
	B. 0.4 to 0.5		2
	C. 0.6 to 0.9		3
	D. 1.0 or more	1.87	>4<

TABLE 7b. ISBH LAKE EUTROPHICATION INDEX (CON'T.)
BEAVER CREEK RESERVOIR - AUGUST 24, 1990

Parameter and Range	Range Observed	Eutrophy Points
VI. Dissolved Oxygen (Percent Saturation at 5 ft. from surface)		
A. 114% or less	102%	>0<
B. 115% to 119%		1
C. 120% to 129%		2
D. 130% to 149%		3
E. 150% or more		4
VII. Dissolved Oxygen (Percent of water column with D.O. ≥ 0.1 ppm)		
A. 28% or less		4
B. 29% to 49%	42%	>3<
C. 50% to 65%		2
D. 66% to 75%		1
E. 76% to 100%		0
VIII. Light Penetration Secchi Disc		
A. Five feet or under	2.54 ft.	>6<
IX. Light Transmission (Percent at 3 ft.)		
A. 0 to 30%	15%	>4<
B. 31% to 50%		3
C. 51% to 70%		2
D. 71% and up		0
X. Total Plankton per ml: (Vertical tow from 5 ft. to surface)		
A. Less than 4700/L		0
B. 4,701 to 9,500/L		1
C. 9,501 to 19,000/L	10,899	>2<
D. 19,001 to 28,000/L		3
E. 28,001 to 57,000/L		4
F. 57,001 to 95,000/L		5
G. More than 95,000/L		10
H. Blue-green dominance		>5 additional points<
(Vertical tow of 5 ft. through thermocline)		
A. Less than 9,500/L	7,240	>0<
B. 9,501 to 19,000/L		1
C. 19,001 to 47,000/L		2
D. 47,001 to 95,000/L		3
E. 95,001 to 190,000/L		4
F. 190,001 to 285,000/L		5
G. More than 285,000/L		10
H. Blue-green dominance		>5 additional points<
EUTROPHICATION INDEX		34

Conclusion of the Resampling

The resampling data provided additional insight into the chemistry of the individual lake strata. The distribution of points throughout the eutrophication index changed from 1989 to 1990, as would be expected by sampling any lake in two different years, but overall the final index value was very consistent.

3.2 Influent Water Quality

The influent water quality data are presented in Table 8. The data show that there are minimal concentrations of ammonia in the influent from all the subwatersheds. There are significant concentrations of nitrate-nitrogen in the influent from subwatersheds 1 and 2 and particularly subwatershed 3 with a concentration of 0.99 mg/L. Total Kjeldahl nitrogen concentrations were moderate to high at all influent points, notably subwatersheds 2 and 4 where concentrations were 2.8 and 2.9 mg/L respectively. Dissolved phosphorus was generally at concentrations below detection limits. However, total phosphorus was at moderately-high concentrations at all influent points, except at subwatershed 5 where the concentration was low. Suspended solids ranged from a low of 40 mg/L at BC-S5 to an excessive 1268 mg/L at BC-S2.

The results of fecal bacteria counts sampled near the lake influent points (BC-1 through BC-5) the lake pool station (BC-6) and near one of the developed recreational areas (BC-7) are presented in Table 9. Significant bacteria counts were present at points BC-1, BC-4 and BC-5. Monitoring point BC-1 had a high fecal coliform count of 1200 with a FC/FS ratio of 25 that keys the contamination to be derived from human wastes. Monitoring point BC-5 also showed moderate contamination attributable to human waste, while point BC-4 shows contamination to be mixed pollution from human and livestock or poultry wastes.

TABLE 8. BEAVER CREEK RESERVOIR

INFLUENT WATER QUALITY ANALYSIS

SAMPLED ID	DATE	TIME	pH	NH_3-N mg/L	NO_3-N mg/L
BC-S1	1 Sept. 89	0640	6.3	0.16	0.59
BC-S2	1 Sept. 89	0350	6.3	0.19	0.51
BC-S3	1 Sept. 89	1200	7.1	0.12	0.99
BC-S4	1 Sept. 89	0300	7.4	0.06	<0.05
BC-S5	1 Sept. 89	0440	7.2	0.03	<0.05

NH_3-N = Ammonia as Nitrogen
NO_3-N = Nitrate as Nitrogen
TKN = Total Kjeldahl Nitrogen
DP = Dissolved Phosphorus
TP = Total Phosphorus
TSS = Total Suspended Solids

TABLE 9. BEAVER CREEK RESERVOIR FECAL BACTERIAL RESULTS

SAMPLE ID	DATE	FECAL COLIFORM C/100 ml	FECAL STREP C/100 ml	RATIO FC/FS
POOL (BC-6)	02 Oct 89	130	12	N/A
BC-1	02 Oct 89	1200	48	25
BC-2	02 Oct 89	62	20	N/A
BC-3	02 Oct 89	45	30	1.5
BC-4	02 Oct 89	246	132	1.9
BC-5	02 Oct 89	230	25	9.1
BC-7	02 Oct 89	84	8	N/A

AVERAGE INDICATOR DENSITY PER GRAM OF FECES

SOURCE	FECAL COLIFORM MILLION	FECAL STREPTOCOCCI MILLION	RATIO FC/FS
Human	13.0	3.0	4.4
Sheep	16.0	38.0	0.4
Cow	0.23	1.3	0.2
Turkey	0.29	2.8	0.1
Pig	3.3	84.0	0.04

(Data from Bureau of Water Hygiene, Environmental Protection Agency, Cincinnati, Ohio.)

FC/FS 4.0 - Ratio greater than or equal to 4 indicates pollution derived from human wastes.

FC/FS 0.7 - Ratio less than or equal to 0.7 indicates pollution derived from livestock or poultry.

FC/FS 2-4 - Ratio between 2 and four suggests a predominance of human wastes in mixed pollution.

FC/FS 0.7-1.0 - Ratio between 0.7 and 1.0 suggests a predominance of livestock or poultry wastes in mixed pollution.

3.3 Sedimentation

Sediment core samples were taken at four predominant inlet points in sediment deltas that have formed in the reservoir. These samples were composited through the sediment layers to the approximate original lake bottom. Each core was analyzed with no detectable concentrations of pesticides, herbicides or metals present. The nutrient summary is provided in Table 10 with the original laboratory analysis sheets provided in the Appendix.

TABLE 10. BEAVER CREEK RESERVOIR SEDIMENT NUTRIENT DATA

SAMPLE ID	DATE	NH_3-N mg/Kg	NO_3-N mg/Kg	TKN mg/Kg	DP mg/Kg	TP mg/Kg	TS
BC-1	09 Aug. 89	90.9	<0.05	1140	<0.05	284	67%
BC-2	09 Aug. 89	52.4	<0.05	1060	<0.05	351	68%
BC-3	09 Aug. 89	209.0	<0.05	2100	<0.05	466	56%
BC-4	09 Aug. 89	89.9	<0.05	1380	<0.05	320	64%

NH_3N = Ammonia as Nitrogen
NO_3N = Nitrate as Nitrogen
TKN = Total Kjeldahl Nitrogen
DP = Dissolved Phosphorus
TP = Total Phosphorus
TS = Total Solids

The readily plant-absorbable nutrients of nitrate-nitrogen and dissolved phosphorus were at undetectable concentrations at all sampling points assumed to be depleted by the extensive aquatic plant populations. Ammonia, total Kjeldahl nitrogen and total phosphorus were at high concentrations at points BC-1, BC-2, and BC-4 and at excessively high concentrations at point BC-3.

Sediment volumes were determined by measuring water depths at the five primary inlets in order to construct profiles and contour maps. These data were compared to the pre-impoundment topography and elevation data on the U.S.G.S. Dubois 7.5-Minute Quadrangle Map dated 1969 (This 1969 map was created from the following data: The planimetry by photogrammetric methods from aerial photographs taken 1949, the topography by planetable surveys 1954, Revised from aerial photographs taken 1968, field checked 1969.) Table 11 provides the approximated sediment volumes at the monitored inlets and an estimated total sediment volume figure for these inlets of 106,378 cubic yards.

TABLE 11. BEAVER CREEK RESERVOIR INLET SEDIMENT VOLUME

SAMPLE ID	VOLUME CUBIC FEET	VOLUME CUBIC YARDS
Inlet-1	360,000	13,333
Inlet-2	660,500	24,463
Inlet-2A	113,600	4,207
Inlet-3	663,400	24,570
Inlet-4	1,074,700	39,806
Inlet-5	239,400	8,867
Total	2,872,200 ft^3	106,378 yd^3

Comparison of the approximate lake surface areas as shown on the 1969 quadrangle map and the 1989 aerial photograph results in an apparent loss in lake surface area of approximately 9.3 acres along the lake fingers. The U.S. Army

Corps of Engineers Phase I Inspection Report dated April of 1980, reported the lake surface area at 173 acres. This data points to an apparent total loss of 16 acres (9 percent) of the lake surface area. This report also listed an approximate storage volume of 2550 acre-feet. Current calculations of 157 acres and a mean depth of 12.9 feet calculate a current approximate storage volume of 2025 acre-feet, for a net loss of 525 acre-feet or 21 percent of the total lake volume. Though this loss in lake volume may be over estimated, based on these surface area figures, at least 9.5 percent of the lake volume has been lost due to sedimentation assuming no decrease in mean lake depth.

3.4 Aquatic Macrophyte Vegetation

Extensive populations of macrophytes occurred at virtually all the lake inlets and along the shoreline of the lake. Bushy pondweed or northern naiad, (Najas flexitis), was found throughout the lake inlets and along most of the shoreline at depths up to six feet. Pondweeds (Potamogeton spp.) were present and in two different field appearances: floating leaves with long, meandering stems rooted in up to two feet of water, and floating masses unrooted without leaves. Quillwort (Isoetes englemanni) was in shallow water, less than one foot deep, near boat docks. Burreed (Sparganium chlorocarpum) was growing along the shoreline associated with cattails (Typha spp.). Other recorded aquatic plant species are bulrushes (Scirpus spp.), spike rushes (Eleocharis spp.), arrowhead (Sagittaria spp.), as well as brittle naiad (Najas minor) and waterthread (Potamogeton diversifolus). In earlier fish management reports (1966, 1968, 1977) naiads were recorded at problem levels in the upper coves. Photographic documentation is provided in the Appendix.

3.5 Watershed Analysis

The watershed of Beaver Creek Reservoir is predominantly forest as shown in Table 12 and on the Beaver Creek Reservoir

Watershed Land Use Map (Appendix). Forest lands comprise 62.9 percent, while agricultural lands total 29.1 percent of the watershed (cropland - 7.3 percent, pasture - 20.8 percent, feedlots - 1.0 percent). Permanent residential areas total 4.7 percent, part-time residential/recreational areas total 2.4 percent, with ponds and small lakes at 0.3 percent and roads at 0.6 percent.

TABLE 12. BEAVER CREEK RESERVOIR WATERSHED ANALYSIS IN ACRES

WATERSHED SECTION	RESIDENTIAL	RECREATIONAL	CROPLAND	PASTURE	FEEDLOT	FOREST	WATER	ROAD	TOTAL
1	7.4	---	38.7	60.0	---	71.0	---	2.1	179.2
1A	10.1	---	---	54.7	---	59.3	0.1	0.7	124.9
1B	---	---	---	2.6	---	12.6	---	---	15.2
2	20.3	---	---	56.7	5.5	74.8	---	2.7	160.0
2A	---	---	---	20.8	---	29.5	---	---	50.3
2B	---	---	---	12.2	---	11.8	0.1	---	24.1
2C	12.3	---	---	6.9	---	24.2	---	0.8	44.2
2D	---	13.9	---	13.0	---	59.7	---	---	86.6
3	32.9	---	56.6	71.0	---	164.4	3.1	4.0	332.0
3A	---	11.6	---	7.1	---	55.2	---	---	73.9
3B	1.6	12.0	---	40.9	---	54.8	---	---	109.3
4	24.9	---	64.8	65.3	5.6	458.7	2.7	2.5	624.5
4A	---	8.0	---	8.7	---	47.5	---	---	64.2
4B	---	---	---	---	---	22.7	---	---	22.7
5	---	---	13.4	26.9	---	169.9	---	---	210.2
5A	---	---	---	---	---	9.9	---	---	9.9
5B	---	6.8	---	9.8	8.4	90.9	---	---	115.9
5C	2.7	3.8	---	36.3	5.3	72.5	0.5	1.3	122.4
TOTAL ACRES	112.2	56.1	173.5	492.9	24.8	1489.4	6.5	14.1	2369.5
PERCENTAGES	4.7%	2.4%	7.3%	20.8%	1.0%	62.9%	0.3%	0.6%	100%

Table 13 demonstrates the subwatersheds that were monitored for nutrient loading and sedimentation during a significant storm event. Surface runoff originating from these monitored subwatersheds accounts for 63.6 percent of the total area of the lake watershed (See Beaver Creek Reservoir Watershed Land Use Map in the Appendix for subwatershed locations).

Examination of the Beaver Creek Reservoir Soils Map (Appendix) will reveal that potentially highly erodible land (HEL soils) occurs within 97 percent of the lake watershed. Non-HEL soils occur only along the lake tributaries, 3 percent of the total watershed. As shown in Table 14, the agricultural land uses occur on these HEL soils almost exclusively (98 percent) other than limited acres in pasture or row crops on Stendal and Cuba soils adjacent to the southern lake tributaries.

A field survey and review of the township plat book indicated that the City of Jasper owns 323.2 acres, inclusive of the reservoir surface area and adjacent lands on part of the eastern half of the reservoir (Appendix). The remaining lake shore property is owned primarily by two private individuals and one incorporated farm.

Of the lake shore owners, three out of four have divided the lake shore property into lots available for annual leasing for recreational purposes. The City of Jasper has 48 lots, 45 of which are leased, with Fritch Farms, Inc. at 47 lots and Mr. Beckman at 73 lots. Temporary and semi-permanent residential structures as well as cottages and small cabins rim the lake shore.

A water and sewage survey by the City of Jasper and Dubois County Health Department was sent out to the lot residents to determine length of residence on the lake, water source, annual water consumption, and type of sewage disposal system (n = 162). A 79.6 percent response was received from the lot residents. It was determined from the volunteered information that the average recreational users of leased lots utilize their lot during summer vacations and weekends throughout the year (49 percent), carry in their water (68 percent) and have

TABLE 13. BEAVER CREEK RESERVOIR
MONITORED SUBWATERSHED ANALYSIS IN ACRES

SUBWATERSHED	RESIDENTIAL	RECREATIONAL	CROPLAND	PASTURE	FEEDLOT	FOREST	WATER	ROAD	TOTAL
1	7.4	---	38.7	60.0	---	71.0	---	2.1	179.2
2	20.3	---	---	56.7	5.5	74.8	---	2.7	160.0
3	32.9	---	56.6	71.0	---	164.4	3.1	4.0	332.0
4	24.9	---	64.8	65.3	5.6	458.7	2.7	2.5	624.5
5	---	---	13.4	26.9	---	169.9	---	---	210.2
TOTAL ACRES	85.5	---	173.5	279.9	11.1	938.8	5.8	11.3	1505.9
PERCENTAGES	3.6%	---	7.3%	11.8%	0.5%	39.6%	0.3%	0.5%	63.6%

TABLE 14. HIGHLY ERODIBLE LAND ANALYSIS
BY MONITORED SUBWATERSHED

SUBWATERSHED	AGRICULTURAL LAND USE ACRES	HEL SOILS	NON-HEL SOILS
1	98.7	100%	0%
2	62.2	95%	5%
3	127.6	100%	0%
4	135.7	97%	3%
5	40.3	100%	0%
TOTALS	464.5	98% AV	2% AV

an outhouse for sewage disposal (58 percent). Two percent were characterized as year-round residents. Twenty percent of the lots have holding tanks for sewage disposal, with four percent having septic tanks. Twenty-seven percent of the lots have Dubois Water Utility hookups, while three percent use the reservoir as their water source. The complete survey analysis is provided in the Appendix.

3.6 Hydrologic Conditions

Of interest concerning the hydrology of Beaver Creek Reservoir is the hydraulic detention time. In theory, the hydraulic detention time is the length of time required for the total volume of the lake to be replaced. This can be estimated by the mean annual runoff, watershed area and lake volume.

The average annual rainfall for the Jasper-Dubois area is approximately 45 inches. The annual runoff determined for Dubois County is 16.0 inches. Thus, the 2369.5 acre watershed would produce 3159 acre-feet of water per year. The lake would receive 590 acre-feet of rainfall directly. The lake would lose approximately 375 acre-feet of water per year due to evaporation from the lake surface. This combines for an average annual net inflow of 337.4 acre-feet or 1,099,346,371 gallons per year. The approximated average lake volume is 661,000,000 gallons. The lake's detention time calculates out to be approximately 0.60 year or 7.2 months. This is the theoretical length of time it would take for the lake water volume to be replaced assuming normal average rainfall.

3.7 Computer Modeling

The program used for modeling sediment and nutrient loading into Beaver Creek Reservoir was the Agricultural Non-Point Source Pollution Model (AGNPS) developed in part by R. A. Young and C.A. Onstad at the USDA North Central Soil Conservation Research Laboratory in Morris, Minnesota.

The reservoir and its watershed were sectioned into 40-acre cells for analysis with some cells further divided into 10-acre cells for greater detail (See AGNPS Computer Model Section of

the Appendix for maps with cell number identifications). This analysis consisted of determining slope, aspect of flow, soil characteristics, cropping practices, fertilization rates and feedlot areas. The sediment and nutrient loading were modeled for a theoretical 25-year/24-hour storm event with an energy-intensity value of 168.

Analysis of the 25 year/24 hour storm event is as follows: The watershed summary determined that the soluble nitrogen concentration at the lake outlet was moderately-high at 1.23 ppm, with soluble phosphorus concentrations moderate, but significant, at 0.14 ppm. Total nitrogen in the sediment was at 0.29 lbs/acre, with total phosphorus at 0.15 lbs/acre. The sediment analysis shows that of the 106.4 tons of sediment yielded to the lake pool station, 95 percent would be clay.

Further analysis of the condensed soil loss data and nutrient analysis data is provided in Table 15, with all five inlet points represented by subwatershed number as designated on the Watershed Map. This table points to subwatersheds 1, 3 and 4 for significant sediment and nutrient loading. Subwatersheds 1 and 3 show the greatest loading of water soluble nitrogen and phosphorus, while subwatershed 4 shows the greatest sediment loading. The sediment deposit tonnage is the amount of sediment that is deposited in each of these 10-acre cells with the yielded tonnage the amount passing on to the reservoir during a storm event of this intensity. Theoretically, 1049.12 tons of sediment would be deposited in the reservoir during a storm event of this intensity with an additional 1005.39 tons deposited in the lake inlets.

TABLE 15. BEAVER CREEK RESERVOIR AGNPS MODEL

5.2 INCH, 25-YEAR/24-HOUR STORM
ENERGY-INTENSITY VALUE OF 168

WATERSHED				RUNOFF	SEDIMENT		NITROGEN			PHOSPHORUS		
Section	Acreage	Weighted RCN	Outlet Cell No.	Peak Rate (cfs)	Deposit (Tons)	Yield (Tons)	Sediment (lbs/Ac)	Water Sol. (lbs/Ac)	(ppm)	Sediment (lbs/Ac)	Water Sol. (lbs/Ac)	(ppm)
1	179.2	76	22/100	318	491.27	53.20	0.89	1.15	2	0.44	0.18	0
2	160.0	75	34/200	351	33.83	143.57	2.10	0.64	1	1.05	0.06	0
3	332.0	76	36/200	523	64.45	395.01	3.49	1.33	2	1.74	0.21	0
4	624.5	75	26/200	718	399.15	355.19	2.00	0.62	1	1.00	0.06	0
5	210.2	74	16/200	511	16.69	102.15	1.78	0.61	1	0.89	0.06	0

To facilitate modeling land treatments where water quality would be improved most effectively, critical cells were identified for sediment and nutrient pollution: Cell 32/400 (10 acres) soybean fields; Cell 42/300 (10 acres) conventionally-tilled corn fields; Cell 42/400 (10 acres) conventionally-tilled corn fields; Cell 44 (40 acres) soybean fields; Cell 45 (40 acres) soybean fields and pasture; Cell 60 (40 acres) soybean fields and limited pasture (See AGNPS Computer Model Section of the Appendix for maps with cell number identifications).

In manipulating the data regarding field conditions, crops and feedlots, identified critical sediment and nutrient sources were mitigated by permanently vegetating highly-erodible corn and soybean fields to pasture - Treatment 1. Further manipulation of the data was done by improving the surface conditions and increasing the buffer zone widths for feedlots located in cells 59 and 60 - Treatment 2. The comparison of the watershed summaries and sediment analyses is provided in Table 16.

By implementing permanent cover on these highly-erodible cropfields comprising only 6 percent (150 acres) of the watershed, dramatic improvements in water quality and soil erosion are predicted. In comparing current conditions to modeled conditions under Treatment 1, weighted upland erosion decreased by 50 percent from 1.93 tons/acre to 0.97 tons/acre. Suspended solids concentration in the runoff decreased by 43 percent. Associated nutrients in sediment decreased by approximately 40 percent. Soluble nutrients in runoff decreased by 16 percent for nitrogen and 36 percent for phosphorus, with soluble COD reduced by 9 percent.

Though there was a modeled decrease of 3 percent soluble nitrogen in the runoff, no other change in sediment or nutrient quantities was apparent in the additional implementation of Treatment 2.

Additional AGNPS data is provided in the Appendix.

TABLE 16. BEAVER CREEK RESERVOIR AGNPS MODEL COMPARISON OF LAND TREATMENTS

PARAMETER	CURRENT CONDITIONS	TREATMENT 1*	TREATMENT 2**
Sediment Analysis			
Upland Erosion	1.93 tons/acre	0.97 tons/acre	0.97 tons/acre
Suspended Solids Conc.	134.90 ppm	77.21 ppm	77.21 ppm
Suspended Solids Yields	106.40 tons	59.50 tons	59.50 tons
Watershed Summary			
Total Nitrogen Sediment	0.29 lbs/ac	0.18 lbs/ac	0.18 lbs/ac
Soluble Nitrogen Runoff	1.23 ppm	1.04 ppm	1.01 ppm
Total Phosphorus Sediment	0.15 lbs/ac	0.09 lbs/ac	0.09 lbs/ac
Soluble Phosphorus Runoff	0.14 ppm	0.09 ppm	0.09 ppm

*Treatment 1: Convert critical NPS sources to permanent cover (pasture/wildlife/forest).

**Treatment 2: Treatment 1 with increased buffer zone, improved pasture on feedlots 59 and 60.

3.8 Data Summary

To provide for clarity and brevity of the pertinent data concerning the eutrophication of Beaver Creek Reservoir, the following summary is provided for the major subwatersheds and the lake noting significant data. The Beaver Creek Reservoir Watershed Land Use Map, included in the Appendix, can be referenced as a visual aid.

Subwatershed 1 Of 179.2 total acres, 98.7 acres (55 percent) is agricultural including soybean fields along tributaries, as well as additional corn and soybean fields and pasture lands. Runoff from this subwatershed is moderately-high in nitrate-nitrogen, total Kjeldahl nitrogen and total phosphorus, with significant total suspended solids. There is human sewage pollution occurring with fecal coliform counts at 1200 C/100 ml exceeding all potable/recreational water quality criteria. There is a significant accumulation of nutrient-rich sediment in the inlet. Contains AGNPS cells 32/400 and 44.

Subwatershed 2 Of 160.0 total acres, 62.2 acres (39 percent) is agricultural including pasture lands and a hog lot. Runoff from this subwatershed is moderately-high in nitrate-nitrogen, total Kjeldahl nitrogen and total phosphorus. Excessive total suspended solids (1268) were concentrated in the runoff. No significant bacterial contamination was evident. There is a significant accumulation of nutrient-rich sediment in the inlet. Contains AGNPS cell 45.

Subwatershed 3 Of 332.0 acres, 127.6 acres (38 percent) is agricultural including cropped fields of corn and soybeans and grazed pasture lands. Runoff from this subwatershed is moderately-high in nitrate-nitrogen, total Kjeldahl nitrogen and total phosphorus. No significant bacterial contamination was evident. There is a significant accumulation of nutrient-rich sediment in the inlet. Contains AGNPS cells 59 and 60.

Subwatershed 4 Of 624.5 acres, 135.7 acres (22 percent) is agricultural including cropped fields of corn and soybeans, grazed pasture lands and a hog lot. Runoff from this watershed is high in total Kjeldahl nitrogen and moderately-high in total phosphorus with significant total suspended solids. There is pollution from human and livestock sources evidenced by concentrations of fecal coliform (246 C/100 ml) and fecal streptococcus (132 C/100 ml), and a FC/FS ratio of 1.9. There is significant accumulation of nutrient-rich sediment and development of deltas in the inlet. Contains AGNPS cells 42/300 and 42/400.

Subwatershed 5 Of 210.2 acres, 40.3 (19 percent) is agricultural including corn fields and pasture lands. Runoff from this subwatershed is moderate in total Kjeldahl nitrogen and low in total suspended solids. There is human sewage pollution evidenced by concentrations of fecal coliform (230 C/100 ml), and a FC/FS ratio of 9.1. There is moderately-significant sedimentation of the inlet.

Beaver Creek Reservoir The lake is characterized as a warm, fertile reservoir with a surface area of 157.3 acres, a mean depth of 12.9 feet and a maximum depth of 29.0 feet. The in-situ water data, laboratory water analysis and algal population counts characterize the lake as having intermediate water quality while exhibiting the potential for excessive algae and aquatic weed problems. Three of the algal species present are noted for algal blooms, odor problems, and other water quality problems. Fecal bacteria contamination was evident at specific inlets as previously noted. The watershed is approximately one-third agricultural on predominantly highly-erodible soils.

SECTION 4. RESTORATION ALTERNATIVES

Lake management techniques for moderate to advanced eutrophication lakes are shown in Table 17. The main management priority, which will improve water quality most effectively on both a short and long term basis, is the limitation of nutrient inputs (IDEM, 1986).

TABLE 17. LAKE MANAGEMENT TECHNIQUES

PRIORITY	DESCRIPTION
1. Wastewater Treatment	a. Treatment plants for communities in the watershed b. Septic tank maintenance programs
2. Watershed Management	a. Buffer zones for agricultural areas adjacent to lake and tributaries b. Protection of wetland areas c. Erosion control d. Zoning and development regulation
3. In-Lake Restoration	a. Macrophyte harvesting b. Chemical controls c. Sediment Consolidation d. Dilution/flushing

4.1 Wastewater Treatment

A septic tank, holding tank and privy maintenance program along the lake shore and the lake tributaries should be enacted to systematically insure that individual systems, as well as public restroom facilities, are properly functioning in the storage or treatment of wastes. Those residents found to be out of compliance with state codes and city regulations regarding sewage disposal would bear the cost of bringing their waste systems up to code. Monitoring techniques for detection of systems out of compliance could include dye studies, water sampling, visual observation, and/or the use of septic leachate detectors (Appendix for sample information). With the continuing recreational and residential development of the lake shore, the fecal coliform counts on three out of five lake inlets, and the city's concern over the long-term quality of their secondary potable water supply, a prudent management response concerning sewage disposal and storage is necessary.

No other typical wastewater treatment method is viable due to the lack of any treatment plant in the vicinity of the reservoir or its watershed and the seasonal usage of the residences. An alternative response to future residential development and/or improvement of public restroom facilities would be the implementation of composting toilets and graywater recycling systems (Appendix for sample information).

4.2 Watershed Management

Due to the close proximity of agricultural land uses and recreational/residential development, buffer zones should be established along the lake shore and its tributaries. These buffer zones would consist of grasses, shrubs and/or trees to provide a vegetative filter for the absorption of nutrient runoff and retention of eroded soil. They would range in width from 66 to 99 feet based on soil type and land slope as recommended by the USDA Soil Conservation Service (SCS, 1989). As can be noted by the examination of the photographs and the watershed map (See Beaver Creek Reservoir Watershed Land Use Map included in the Appendix), recreational development and

associated loss of natural ground cover are evident along nearly the entire shoreline. In addition, cropland is located along the tributary of the western finger of the lake. This cropland, though not highly erodible land, may be eligible for the Conservation Reserve Program as a vegetative filter strip along a stream and lake if it has been cropped for at least two years from 1981 to 1985 (EPA, July 1988).

There are no natural wetland areas on the watershed except where inlets have accumulated sediments providing for the establishment of wetland plant species.

There are farms on subwatersheds 2 and 4 with hog lots that have no known waste management system to provide for the retention and proper disposal of animal wastes. The eastern finger of the lake, specifically subwatershed 4, exhibits animal waste contamination evident by fecal bacteria counts that could be keyed to this hog lot or to liquid hog manure application to crop fields on this subwatershed. The high organic nitrogen levels in the storm runoff could also be keyed to these potential sources.

Appropriate Best Management Practices (BMPs) should be implemented by the local SCS office and pertinent landowners in these agricultural subwatersheds. Professional recommendations regarding animal waste management systems, application methods concerning dry chicken manure and liquid hog manure, livestock exclusion areas, conservation tillage, and contour stripcropping need to be reviewed with pertinent farm operators on the Beaver Creek watershed.

Virtually the entire watershed is composed of highly erodible soils with numerous fields in corn or soybeans that are conventionally tilled rather than tilled by the soil-conservative methods of reduced-till or no-till. Several subwatersheds monitored during the storm event have crop fields that were conventionally tilled and planted, specifically subwatersheds 1, 2, 4 and 5. As noted by analyzing the computer modeling data, even a no-till soybean field has a significant soil loss under these specific land conditions. Water and soil erosion control structures (WASCOBS) are located

only on the Hostetter property along State Road 164. Additional WASCOBS are needed along eroded field edges and eroded drainage channels in cropped and pasture fields, with severely eroding fields managed under T by 2000 objectives and programs such as set-aside acres or CRP acres.

The original circumstance causing the severely eroded hillside in subwatershed 5c is not known. Several years ago, the landowner consulted the district forester and implemented a revegetation plan including the planting of 4000 redcedar trees (Juniper virginiana). The revegetation has been successful.

It is known through visual inspection, that stream channel erosion is a factor of the sediment loading throughout the watershed though no specific data was recorded. It is also believed that there is gully erosion in part of the forested area of subwatershed 4 based on interpretation of the SCS soils map. The highly erodible nature of the soils, the steep topography, the location and method of cropped fields, as well as the large drainage area combine for significant siltation to occur at the inlet of subwatershed 4. The remote location of the inlet of subwatershed 5, in addition to the previous details, further precludes any other management technique besides the control of eroding soils from cropland.

A final watershed management technique is the implementation of zoning ordinances or development regulations along the lake shore. Numerous individuals mentioned during the study that there is an unwritten understanding that there is not to be any permanent structures, nor permanent residents along the lake shore. However, there are at least six cabins or trailers that have full-time residents, and there are two proposed permanent residences on the lake shore even though the lots are leased annually. For the long-term quality of the reservoir, specific detailed regulations regarding lake shore development and residential use should be implemented.

4.3 In-lake Restoration

One response to the problem of excessive aquatic plant growth is to actively manage the plants by harvesting them.

Most species of submergent and emergent aquatic macrophytes can be removed in front of private cabins or boat docks by lake residents using hand held weed harvesters. These macrophytes assimilate the nutrients from the water and fix them permanently in their tissues. Consequently, the removal of the plants not only contributes to aesthetics and access to the lake, but is an effective way to remove nutrients from the lake ecosystem which may contribute to the growth of algae. The process of harvesting is easy and price effective (Appendix). The aquatic macrophyte harvester can be cast from a dock or the lake shore and drawn through the macrophyte bed. After the macrophytes float to the top of the water, they should be collected and disposed of in an area where the nutrients will not run back into the lake after the plants decay. Commonly, these harvested plants are used on gardens or put in compost piles located away from the lake shore. After several harvestings of the macrophytes, the plants eventually become stressed to a point that they no longer grow back. As an example, cattails will usually die after three cuttings below the water line.

Chemical treatment is another alternative which could be implemented when aquatic plant growth is excessive in specific lake shore areas, such as residential areas and public access points. Chemical treatments have been conducted on the lake intermittently since 1966 using Diquat, Komeen, and Sonar recently, as permitted by the Indiana State Board of Health for secondary potable water facilities. Cost of treatment has averaged $300 per acre. Caution should be made for the application of these herbicides by a licensed pesticide applicator familiar with aquatic plant management. It is also necessary that some aquatic plants be maintained in coves and inlets to provide for fish habitat areas as consistently stated by Division of Fish and Wildlife personnel.

Under certain conditions, a different kind of chemical treatment could be implemented. This type of chemical treatment will remove nutrients from the water which consequently inhibits the growth of aquatic vegetation and

algae. The first method involves the application of aluminum sulfate or sodium aluminate which removes the phosphorus from the water column and suppresses the release of phosphorus from the sediments. This would be effective during certain times of the year when high levels of phosphorus are present in the lake water. The second method involves the application of certain iron and calcium compounds which consequently will inhibit the release of nutrients from the sediments which often occurs under anoxic, highly reducing conditions in the hypolimnion (cool, bottom water). Details of the lake's morphology, climatic conditions, thermal structure, and seasonal changes in specific nutrient forms and quantities could have significant effects on these kinds of treatment techniques and the associated costs of application. The reduction of nutrient loading to the lake is a prerequisite for this treatment to be feasible and have any long-lasting effects. These treatments have only recently been applied in the United States and Europe as a lake treatment method. A sample information sheet is provided in the Appendix.

Another in-lake restoration method is the partial consolidation and inactivation of sediments by drawing down the lake. The water content of organic-rich sediments frequently exceeds 90 percent by volume (IDEM, 1986). Consolidation by desiccation of these sediments is irreversible and results in the decrease of sediment volume and the stabilization of the upper sediment layers. Though a temporary increase in algal populations may occur due to increased microbial activity and other factors, this method may also have some success in aquatic plant control (IDEM, 1986). However, certain species of aquatic plants actually increase with lake drawdown over the winter, specifically the current problem species of naiad (Najas flexilis), as well as certain species of pondweeds (Potamogeton spp.), broad-leaf cattail (Typha latifolia) and softstem bulrush (Scirpus validus) (Cooke, 1986). Lake drawdown should be alternated every 2 years with no drawdown so that resistant species do not become firmly established (EPA, 1988).

A common in-lake treatment for significant sedimentation and associated excessive aquatic plant populations is dredging. Dredging would physically remove the accumulated sediment at the lake inlets, thus deepening the water channels while removing the roots and rhizomes of aquatic plants. This treatment technique is expensive, however. Average costs can run $2 to $5 per cubic yard not including disposal, transport or monitoring costs and necessary permits from the U.S. Army Corps of Engineers.

A final in-lake technique would be the development of sediment ponds and/or wetland systems in the three predominant inlets of the lake, though this is an expensive technique. As shown in Figures 6 and 7, sediment ponds with wetlands could be constructed in inlets of subwatersheds 1 and 3 providing for the settling of suspended sediments in the ponds with the associated wetlands absorbing the water-soluble nutrients. An estimated cost could run $8.50 per cubic yard. The inlet at subwatershed 4 is a feasible situation for an extensive wetland system based on sediment volume, storm runoff volume and nutrient loads. Estimated cost for wetland construction is estimated to run $10.00 per square meter (U.S. Bureau of Reclamation). Limited plantings of desirable wetland species providing soil stability, nutrient uptake and wildlife benefits would be necessary due to the presence of wetland species and potential seed sources on site, though additional shrub and tree species would be desirable. Inlets at 2, 2a and 5 are not practicable for this technique due to topography and recreational access to cabins, as well as the relative contribution of these subwatersheds to the sediment and nutrient loading problems.

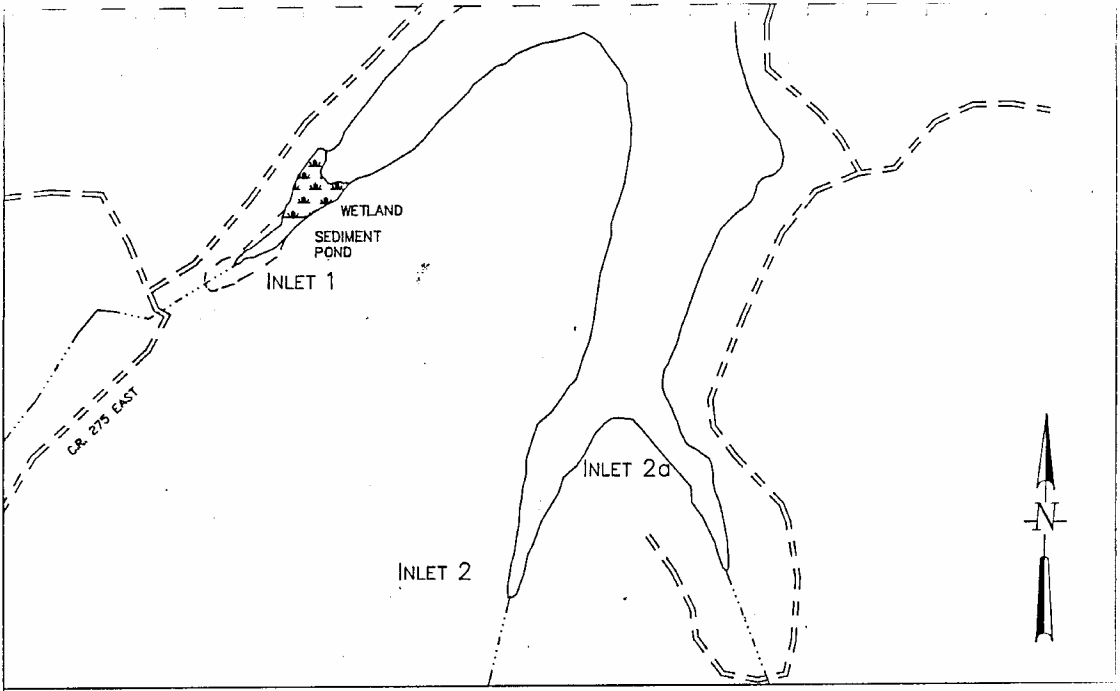


FIGURE 6. IN-LAKE RESTORATION
SEDIMENT PONDS AND WETLANDS

SCALE
0 400
FEET

DONAN ENGINEERING CO., INC.
RT. 3 BOX 403
JASPER, IN 47546

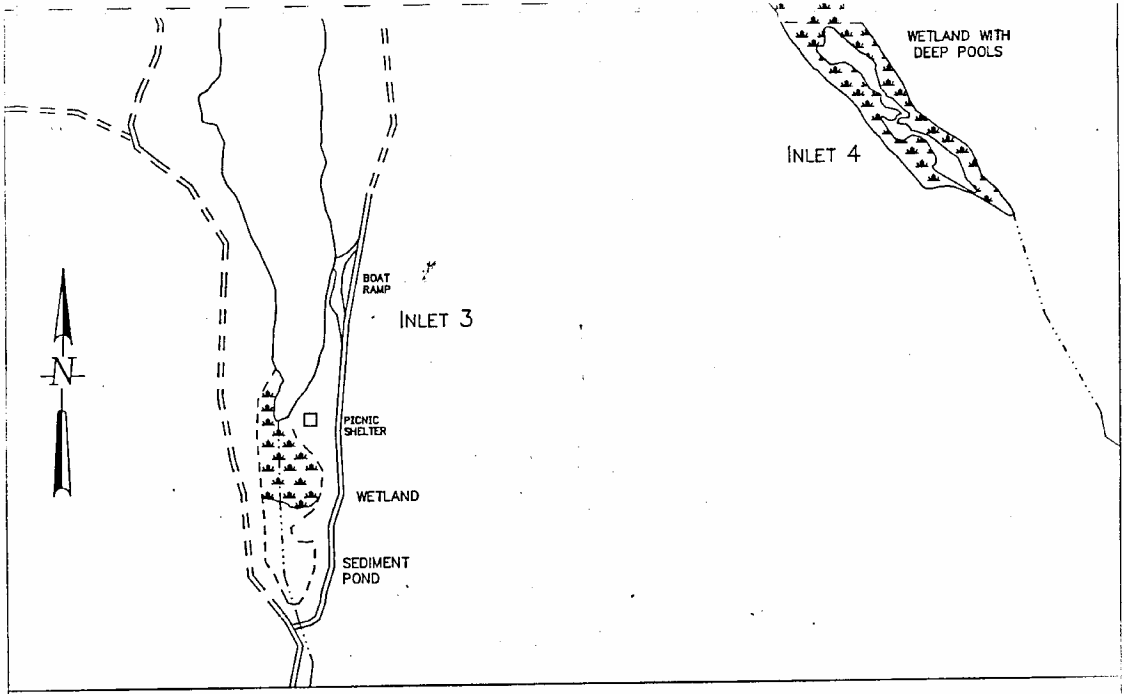


FIGURE 7. IN-LAKE RESTORATION
SEDIMENT PONDS AND WETLANDS

SCALE
0 400
FEET

DONAN ENGINEERING CO., INC.
RT. 3 BOX 403
JASPER, IN 47546

4.4 Current Management

The Jasper Park and Recreation Board distributes a pamphlet listing regulations at Beaver Creek Reservoir regarding sewage and garbage disposal, sewer system permits and inspections, city lot lease agreements, dock and pier construction, as well as fishing and swimming restrictions. According to this pamphlet, the written policy of the Board is that the sewer superintendent, or a designated representative of the City of Jasper, enforces the sanitary regulations at Beaver Creek. This includes any privy, privy vault, septic tank or septic system. A written permit signed by the sewer superintendent is necessary before the beginning or construction of private sewage disposal systems or privies on any lands bordering the lake, with all disposal systems to be constructed and maintained as set in Bulletin S.E. 8 and S.E. 11 of the Indiana State Board of Health. The sewer superintendent also has the authority to inspect, observe, and test any sanitation facility installed upon any land bordering the lake. It further states that the city reserves the power and authority to prohibit, restrict or otherwise limit or regulate the maintenance or operation of any land owned by the city and leased on the lake should it become necessary to do so in the interest of public health or safety, or for the protection or improvement of the lake or other cause.

The active management of the lake and city property has consisted of regulating the necessary fishing and boating licenses, idle zones on the lake, and dock and pier construction. The County Sanitarian has inspected and consulted on septic systems on the lake shore for which permits were filed with the Dubois County Health Department. Management techniques have included lowering the lake pool approximately four feet through the late fall and winter seasons to provide for dock and pier repair and to allow for ice formation. Also included is the application of Diquat, Komeen and Sonar herbicides to control the aquatic plant growth along parts of the shoreline and the recreational areas, though the treatment is not a regular, annual program. In the past,

the Beaver Lake Improvement Association has collected donations from residents and boaters to fund the aquatic plant control program, with some money donated by the Jasper Park and Recreation board.

Continuing the current management techniques will not be sufficient to respond to the multiple problems occurring at Beaver Creek Reservoir. The storage of inoperable vehicles, abandoned fuel oil tanks and corroded metal drums on the lake shore and city property potentially provides for the contamination of the lake with heavy metals and organic chemicals. The dense recreational development, presence of septic systems, unregulated pumping of holding tanks, and number of privies located on the lake shore poses the potential for sewage contamination as well. Under current management techniques, sediment and nutrient loading into the lake will continue, providing for increasing algae and aquatic weed populations, greater sedimentation of coves and inlets, reduction of lake surface area and volume, as well as decreasing water quality. The overall quality of the reservoir as a water supply and a recreational facility will progressively decline.

SECTION 5. PREFERRED ALTERNATIVE

The preferred alternative for Beaver Creek Reservoir responds to numerous factors influencing the lake water quality while addressing cost-effectiveness and recreational lake usage of the secondary potable water supply for the City of Jasper.

The primary response to the sedimentation and nutrient loading of Beaver Creek Reservoir is the implementation of T by 2000 objectives of the state, IDNR, Division of Soil Conservation and the federal, USDA, Soil Conservation Service. Croplands on the watershed are eroding at an excessive rate due to soil characteristics, land characteristics, farming practices, and drainage patterns. This cropland erosion is a significant factor in the sediment and nutrient loading to the lake. Another factor in the nutrient loading is the application of animal manures to cropfields, specifically at inappropriate times or under undesirable conditions. The fertilizer application of dry chicken manure and liquid hog manure, as well as manure from grazed cattle and hog lots on the watershed, are contributing to the nutrient loading and bacterial content of runoff.

Soil conservation technicians and erosion control specialists should contact pertinent agricultural landowners and forest landowners to evaluate soil erosion problems on croplands, pasture lands and possible gully erosion occurring on the watershed. Appropriate and necessary conservation plans should be recommended and developed by implementing numerous state and/or federal cost-share programs such as the federal Conservation Reserve Program, Agricultural Conservation Program, Long-Term Agreements, Long-Term Contracts, and the T by 2000 Cropland Erosion Control Program. Only by significantly reducing the sediment and nutrient loading originating from these agricultural lands will significant improvement of the lake water quality and reduction of sedimentation occur.

Another watershed management response is the implementation of buffer zones along the lake shore and the lake's tributaries. Buffer zones along tributaries in agricultural areas should be addressed by the T by 2000 program, with recreational areas addressed by city zoning and development regulation. The dimensions and vegetation of these buffer zones would be determined by Soil Conservation Service field inspections, with buffers ranging from 66 to 99 feet in width.

The in-lake restoration technique of lake drawdown is recommended, lowering the lake water level by 8 feet over the late fall and throughout the winter alternating every 2 years with no drawdown. This will expose the predominant sedimentation areas to desiccation providing for subsequent increased water depth and decreased nutrient loading by the consolidation of the surface sediment layers. Due to the presence of certain species of aquatic vegetation that may increase due to this drawdown, hand held harvesters should be used to suppress the growth. If harvesting does not control the vegetation an application of aquatic herbicides should be implemented the following year and should be provided for annually until considerable reduction of nutrient loading and aquatic vegetation populations is evident. Any lake drawdown program should be coordinated with the Division of Fish and Wildlife such that the fishery at Beaver Creek Reservoir is not adversely impacted.

Another recommended response is the construction of sediment ponds/wetland systems to further aid in reducing the sediment and nutrient loading of the lake. Even if conservation programs are implemented, a significant amount of sedimentation will occur due to the highly erodible soils and channel erosion occurring throughout the watershed. The critical inlets are at subwatersheds 1, 3 and 4 as discussed earlier (Section 4.3) and as previously shown (Figures 6 and 7). A Construction in a Floodway permit may be required by the Indiana Department of Natural Resources.

A final response is the implementation of a waste management program that would systematically regulate and

enforce the construction and maintenance of waste storage and disposal systems. Records should be kept by the City monitoring septic systems and maintenance, holding tank size and pumping schedules, as well as outhouses with or without holding tanks. All waste systems and their operation should be field checked to verify that these systems meet the recommendations and/or criteria of the Dubois County Health Department and Indiana State Board of Health. If they do not, then the owners of these waste systems should be ordered into compliance.

These responses combine as the preferred alternative for Beaver Creek Reservoir addressing sedimentation, nutrient loading, aquatic plant control and erosion control as shown in Table 18. This set of management techniques or any other management techniques implemented on Beaver Creek Reservoir should be a part of a Lake Management Plan with a foundation already provided in City regulations. A Lake Management Plan should provide for the management of the lake, its tributaries and shoreline, the regulation of recreational lake usage and development including a waste management program, and the systematic monitoring of lake water quality and eutrophication indicators, such as: transparency, odor, bacterial counts, aquatic vegetation and fish populations.

TABLE 18. PREFERRED LAKE MANAGEMENT TECHNIQUES

PRIORITY	DESCRIPTION	COST	FUNDING
1. Watershed Management	a. WASCOBS, BMPs and other T by 2000 land management techniques	a. Cost-share programs with landowners	a. May be funded by SCS, ASCS, and IDNR Div. of Soil Cons.
	b. Buffer zones	b. Cost-share programs with landowners	b. May be funded by SCS, ASCS, and IDNR Div. of Soil Cons.
	c. Zoning & development regulation by the City	c. ---	c. City of Jasper, Park and Rec. Board and Water Utility
2. In-Lake Restoration	a. Lake drawdown	a. ---	a. City of Jasper Water Utility
	b. Aquatic vegetation control	$b._1$. Weed harvesters less than $100 $b._2$. Herbicides @ $300/ac $6000 to $7500	b. Beaver Lake Imp. Assoc., and Jasper Park and Rec. Board
	c. Sediment pond/wetland construction	c. Inlet 1: $ 93,700 est. Inlet 3: $161,700 est. Inlet 4: $237,600 est.	c. May be funded in part by IDNR, Div. of Soil Cons.
3. Wastewater Treatment	a. Waste management program regulation and enforcement	a. ---	a. City of Jasper, Park and Rec. Board, Beaver Lake Superintendent

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APPENDIX

FIELD DATA SHEETS

WATER QUALITY FIELD DATA

LOCATION Beaver Creek Lake BY David Denham

WEATHER Clear

WIND VELOCITY 0-3 AIR TEMPERATURE 78°

COLOR Green CURRENT SPEED -- BARAMETER --

REMARKS Donan Engineering

Site #1

STATION 1 DATE 082490 TIME 0920

DEP	TEMP	D.O.	COND	pH	ORP	TOT ALK	PHTH ALK	MAX DEP	DIST BET BANKS	DIST FROM L.BANK	SECCHI DISK	WATER SURFACE ELEVATION	VELOCITY (fps)	% TRANS
000	26.6	08.5	0122	08.7							31.0	500.0		14.9
003	26.5	08.5	0123	08.3					SAMPLE	PULLED				13.7
006	26.4	08.1	0123	08.2										14.4
007	26.2	07.9	0124	08.5										14.5
008	26.3	04.6	0125	08.5										16.1
009	25.0	00.1	0120	06.5										26.1
012	21.9	00.1	0149	06.6										30.1
015	19.2	00.1	0169	06.7										7.8
018	17.1	00.1	0185	06.6					SAMPLE	PULLED				1.7
019	15.9	00.1	0193	06.6										2.2

WATER QUALITY FIELD DATA

LOCATION BEAVER CREEK LAKE BY David Denham

WEATHER CLEAR

WIND VELOCITY 0-3 AIR TEMPERATURE 78°

COLOR GREEN CURRENT SPEED — BAROMETER —

REMARKS DONAN ENGINEERING
SITE #1

STATION	DATE	TIME	DUPLICATE COLUMNS 1-19 ON ALL CARDS
1	082749	0920	

DEP.	TEMP.	D.O.	COND.	PH	ORP	TOT. ALK.	PHTH. ALK.	MAX. DEP.	DIST. BET. BANKS	DIST. FROM L.BANK	SECCHI DISK	WATER SURFACE ELEVATION	VELOCITY (fps)	% TRANS.
000	26.6	08.6	0172	06.7							31.0	1500.0		14.19
003	26.5	08.6	0123	06.3				SAMPLE	PULLED					13.17
006	26.4	08.6	0123	06.2										14.14
017	26.2	07.9	0124	06.5										14.15
008	26.3	04.6	0126	06.5										16.11
009	25.0	00.1	0120	06.5										26.1
012	21.9	00.1	0149	06.6										30.1
016	19.2	00.1	0169	06.7										07.18
018	17.1	00.1	0185	06.6				SAMPLE	PULLED					01.12
019	15.9	00.1	0193	06.6										02.12

NASHVILLE DISTRICT

WATER QUALITY FIELD DATA

CORPS OF ENGINEERS

LOCATION: Beaver Creek [illegible] BY: EMT, GF, SY

WEATHER: Clear

WIND VELOCITY: ______ AIR TEMPERATURE: 80

COLOR: ______ CURRENT SPEED: ______ BAROMETER: ______

REMARKS: Station near dam.

STATION (1–9)	DATE (10–15)	TIME (16–19)
BLL1	890809	1000

DUPLICATE COLUMNS 1-19 ON ALL CARDS

(Zero-fill columns 1-22)

DEP. (20–22)	TEMP. (23–26)	D.O. (27–30)	COND. (31–34)	PH (35–38)	ORP (39–42)	TOT. ALK. (43–45)	PHTH. ALK. (46–48)	MAX. DEP. (49–51)	DIST. BET. BANKS (52–55)	DIST. FROM L.BANK (56–59)	SECCHI DISK (60–63)	WATER SURFACE ELEVATION (64–69)	Light Transmit. (~~INST. DISCHARGE~~) (70–75)	Turbidity (76–80)
000	259	101	111	82							77	90	% 64	0.0 B 40
005	259	101	111	83								50	58	5.0' 50
010	258	97	111	83								100	57	10.0' 07
015	217	41	120	67								125	57	12.5' 07
020	153	13	185	65								150	53	15.0' 06
025	131	12	213	65								175/15	02	17.5' 4[illegible]
017 [.5]	178	10	154	65								200	01	20.0' 5[illegible]
012 [5]	257	91	111	82								225	01	25.0' 22
												250	01	change sc. TN C
														- - - - -
														25.0' 0[illegible]
														20.0' 0[illegible]
														17.5' 2[illegible]
														15.0' 3[illegible]
														12.5' 4[illegible]
														10.0' 27
														5.0' 29
														0.0' 50

ORN Form 561 CEORN-ED-E

8-9-89

8:30 AM Beaver Lake

BL1 in Front of dam

reading ≈ 30' measured ≈ 25'

Secchi disk 7.7'

some algae floating in globules

sediment 4.5' deep in BLI1 right FK

plant in front of cattails - Emergent
3' length

BLI2 in second left Fork

well defined channel

buffalo grass growing and

plants - emergence with balls - dominant

Lunch

BLI3 sediment sample 8' 4.3'

well defined channel

terr. grass in center + shoreline

Lycopodium extends 100 yds or more to lake

water a little more murky here

BLI-4 8' sediment depth in bar

LAB ANALYSIS SHEETS

Edward G. Foree, Ph.D., P.E.

John S. Tapp, Ph.D., P.E., L.S.

COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: September 18, 1990

CTI LAB NO: L90111350
P. O. NO: N/A

To: CPN8017/Beaver Creek Lake

Attn: Dr. E. G. Foree

REPORT OF ANALYTICAL RESULTS

SAMPLE ID: No. 1-1 (Depth 3 ft.)
SOURCE OF SAMPLE: Beaver Creek Lake
SAMPLE MATRIX: Water
DATE OF COLLECTION: 08/24/90
COLLECTION TIME: 9:20A
COLLECTED BY: D. Denham
DATE RECEIVED: 08/27/90

PARAMETER		RESULTS	UNITS	DETCT LIMIT	SAMP TYPE	METHOD
Nitrogen, Ammonia		0.03	mg/L	0.03	Como	EPA350.3
Nitrogen, Nitrate	<	0.1	mg/L	0.1	Grab	EPA300.0
Nitrogen, Total Kjeldahl		0.77	mg/L	0.03	Grab	EPA351.4
Ortho-Phosphate	<	0.01	mg/L as P	0.01	Grab	EPA365.2
Phosphorus, Total		0.01	mg/L as P	0.01	Grab	EPA365.2

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: September 18, 1990

CTI LAB NO: L90111351
P. O. NO: N/A

To: CPN8017/Beaver Creek Lake

Attn: Dr. E. G. Foree

REPORT OF ANALYTICAL RESULTS

SAMPLE ID: No. 1-2 (Depth 18 ft.)
SOURCE OF SAMPLE: Beaver Creek Lake
SAMPLE MATRIX: Water
DATE OF COLLECTION: 08/24/90
COLLECTION TIME: 9:50A
COLLECTED BY: D. Denham
DATE RECEIVED: 08/27/90

PARAMETER		RESULTS	UNITS	DETCT LIMIT	SAMP TYPE	METHOD
Nitrogen, Ammonia		3.71	mg/L	0.03	Comp	EPA350.3
Nitrogen, Nitrate	<	0.1	mg/L	0.1	Grab	EPA300.0
Nitrogen, Total Kjeldahl		3.82	mg/L	0.03	Grab	EPA351.4
Ortho-Phosphate		0.10	mg/L as P	0.01	Grab	EPA365.2
Phosphorus, Total		0.26	mg/L as P	0.01	Grab	EPA365.2

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: September 18, 1990

CTI LAB NO: L90111352
P. O. NO: N/A

To: CPN8017/Beaver Creek Lake

Attn: Dr. E. G. Foree

REPORT OF ANALYTICAL RESULTS

SAMPLE ID: No. 1 Field Blank
SOURCE OF SAMPLE: Beaver Creek Lake
SAMPLE MATRIX: Water
DATE OF COLLECTION: 08/24/90
COLLECTION TIME: 9:10A
COLLECTED BY: D. Denham
DATE RECEIVED: 08/27/90

PARAMETER		RESULTS	UNITS	DETCT LIMIT	SAMP TYPE	METHOD
Nitrogen, Ammonia	<	0.03	mg/L	0.03	Comp	EPA350.3
Nitrogen, Nitrate	<	0.1	mg/L	0.1	Grab	EPA300.0
Nitrogen, Total Kjeldahl	<	0.03	mg/L	0.03	Grab	EPA351.4
Ortho-Phosphate	<	0.01	mg/L as P	0.01	Grab	EPA365.2
Phosphorus, Total		0.01	mg/L as P	0.01	Grab	EPA365.2

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

CTI Algae Identification

Report Date: 8/12/89

CTI Report No.: MT20030
Project : Beaver Creek Reservoir
Project No.: 345
Identification by: Jeff Stein

To: Mike Tackett

Date of Collection: 8/09/89
Date Received: 8/10/89
Sample Type: Grab
Sampling Depth: As Shown

Scientific Name	Sampling Depth	Concentration #/0.0001 ml
Chlamydomonas Anabaena Platydorina Ulothrix	5.0'	1
Ulothrix Ankistrodesmus Nostoc Anabaena Eudorina	13.5'	4
Nostoc	24'	8

Bag samples from floating masses - Oscillatoria
- Ulothrix

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Aquatic Plants Identification

Report Date: 8/12/89

CTI Report No.: MT20031
Project : Beaver Creek Reservior
Project No.: 345
Identification by: Jeff Stine

To: Mike Tackett

Date of Collection: 8/09/89
Date Received: 8/10/89
Sample Type: Grab

- Sparganium chlorocarpum - burreed was growing along shoreline in very shallow water to dry and was associated with cattails.

- Isoetes engelmanni - quillwort was growing in shallow water less than 1.0 foot deep to 0.0 feet deep near dock.

- Potamogeton spp. - pondweeds had two different field appearances. Near the dock, it had floating leaves on long meandering stems rooted in water up to 2.0 feet deep. At another location it was found floating in masses unrooted and without leaves.

- Najas flexilis - minor Naiad or bushy pondweed was found throughout lake in inlets and along shore lines in 2.0 to 6.0 feet of water.

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BEAVER CREEK RESERVOIR AQUATIC PLANTS

- Sparganium chlorocarpum - burreed was growing along shoreline in very shallow water to dry and was associated with cattails.

- Isoetes engelmanni - quillwort was growing in shallow water less than 1.0 foot deep to 0.0 feet deep near dock.

- Potamogeton spp. - pondweeds had two different field appearances. Near the dock, it had floating leaves on long meandering stems rooted in water up to 2.0 feet deep. At another location it was found floating in masses unrooted and without leaves.

- Najas flexilis - minor Naiad or bushy pondweed was found throughout lake in inlets and along shore lines in 2.0 to 6.0 feet of water.

BEAVER CREEK RESERVOIR ALGAE

5.0'	Chlamydomonas Anabaena Platydorina Ulothrix	1/0.0001 ml
13.5'	Ulothrix Ankistrodesmus Nostoc Anabaena Eudorina	4/0.0001 ml
24'	Nostoc	8/0.0001 ml

Bag samples from floating masses - Oscillatoria
- Ulothrix

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: October 10, 1989

TO: Donan Engineering
RR #3, Box 40H
Jasper, IN 47546

ATTN: Ms. Karen Dearlove

CTI LAB NO: See Below

SOURCE OF SAMPLE: See Below
DATE OF COLLECTION: 10/2/89
DATE RECEIVED: 10/3/89
SAMPLE TYPE: Bacteriological

REPORT ON ANALYSIS OF WATER SAMPLES

LAB ID NO	SAMPLE ID	FECAL COLIFORM	FECAL STREP	FC/FS RATIO
L8911835	BC-1	1200	48	25
L8911836	BC-2	62	20	Strep density was insufficient for a valid FC/FS Ratio
L8911837	BC-3	45	30	1.5
L8911838	BC-4	246	132	1.9
L8911839	BC-5	230	25	9.1
L8911840	BC-6	130	12	Strep density was insufficient for a valid FC/FS Ratio
L8911841	BC-7	84	8	Strep density was insufficient for a valid FC/FS Ratio

FC/FS 4.0 - Ratio greater than or equal to 4 indicates pollution derived from human wastes.

FC/FS 0.7 - Ratio less than or equal to 0.7 indicates pollution derived from livestock or poultry.

FC/FS 2-4 - Ratio between 2 and 4 suggests a predominance of human wastes in mixed polltution.

FC/FS 0.7 - 1.0 Ratio between 0.7 and 1.0 suggests a predominance of livestock or poultry wastes in mixed pollution.

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COMMONWEALTH TECHNOLOGY, INC.

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DATE: 09/12/89

CTI LAB NO: L8909821
P. O. NO:

To: CTI/Job No. 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Beaver L. 24, 13.5, 5 ft.
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Composite
DATE OF COLLECTION: 08/09/89
COLLECTION TIME: 11:00A
COLLECTED BY: CTI
DATE RECEIVED: 08/14/89

8/22/89-L8909821 is a Composite of L8909421, L8909422, & L8909423

PARAMETER		RESULTS	UNITS	DET'T LIMIT
Nitrogen, Ammonia		0.9	mg/L	0.01
Nitrogen, Nitrate	<	0.05	mg/L	0.05
Nitrogen, Total Kjeldahl		23.4	mg/L	0.01
Phosphorus, Dissolved		0.04	mg/L as P	0.01
Phosphorus, Total		0.12	mg/L as P	0.01
Solids, Total Suspended		20	mg/L	1

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: 09/21/89

CTI LAB NO: L8910580
P. O. NO: N/A

To: CTI/Project No. 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 1-1840
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 6:40P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

PARAMETER		RESULTS	UNITS	DET'T LIMIT
Nitrogen, Ammonia		0.16	mg/L	0.01
Nitrogen, Nitrate		0.59	mg/L	0.05
Nitrogen, Total Kjeldahl		1.5	mg/L	0.01
Phosphorus, Dissolved	<	0.01	mg/L as P	0.01
Phosphorus, Total		0.31	mg/L as P	0.01
Solids, Total Suspended		350	mg/L	1

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COMMONWEALTH TECHNOLOGY, INC.

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DATE: 10/05/89

CTI LAB NO: L8911345
P. O. NO: N/A

To: CTI/Project No. 345
Beaver Lake

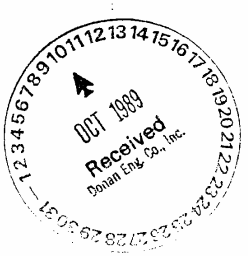
Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 1
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 6:40P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

Additional Parameters Reported-Previous Lab No. L8910580

PARAMETER	RESULTS	UNITS	DET'T LIMIT
pH	6.3	S U	N/A
Solids, Total Dissolved	112	mg/L	1



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Environmental and Natural Resources Consulting and Analytical Services

DATE: 09/21/89

CTI LAB NO: L8910582
P. O. NO: N/A

To: CTI/Project No. 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 2-1550
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 3:50P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

PARAMETER		RESULTS	UNITS	DET'T LIMIT
Nitrogen, Ammonia		0.19	mg/L	0.01
Nitrogen, Nitrate		0.51	mg/L	0.05
Nitrogen, Total Kjeldahl		2.8	mg/L	0.01
Phosphorus, Dissolved	<	0.01	mg/L as P	0.01
Phosphorus, Total		0.67	mg/L as P	0.01
Solids, Total Suspended		1268	mg/L	1

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: 10/05/89

CTI LAB NO: L8911347
P. O. NO: N/A

To: CTI/Project No. 345
Beaver Lake

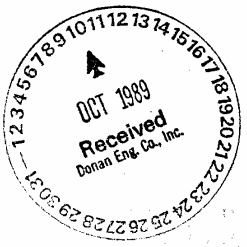
Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 2
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 3:30P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

Additional Parameters Reported-Previous Lab No. L8910582

PARAMETER	RESULTS	UNITS	DET'T LIMIT
pH	6.3	S U	N/A
Solids, Total Dissolved	20	mg/L	1



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Environmental and Natural Resources Consulting and Analytical Services

DATE: 09/21/89

CTI LAB NO: L8910585
P. O. NO: N/A

To: CTI/Project No. 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 3-1200
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 12:00P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

PARAMETER		RESULTS	UNITS	DET'T LIMIT
Nitrogen, Ammonia		0.12	mg/L	0.01
Nitrogen, Nitrate		0.99	mg/L	0.05
Nitrogen, Total Kjeldahl		1.7	mg/L	0.01
Phosphorus, Dissolved	<	0.01	mg/L as P	0.01
Phosphorus, Total		0.21	mg/L as P	0.01
Solids, Total Suspended		157	mg/L	1

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DATE: 10/05/89

CTI LAB NO: L8911350
P. O. NO: N/A

To: CTI/Project No. 345
Beaver Lake

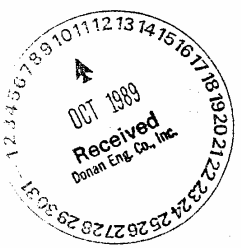
Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 3
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 12:00P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

Additional Parameters Reported-Previous Lab No. L8910585

PARAMETER	RESULTS	UNITS	DET'T LIMIT
pH	7.1	S U	N/A
Solids, Total Dissolved	24	mg/L	1



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DATE: 09/21/89

CTI LAB NO: L8910591
P. O. NO: N/A

To: CTI/Project No. 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 4
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 3:00P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

PARAMETER		RESULTS	UNITS	DET'T LIMIT
Nitrogen, Ammonia		0.06	mg/L	0.01
Nitrogen, Nitrate	<	0.05	mg/L	0.05
Nitrogen, Total Kjeldahl		2.9	mg/L	0.01
Phosphorus, Dissolved	<	0.01	mg/L as P	0.01
Phosphorus, Total		0.28	mg/L as P	0.01
Solids, Total Suspended		391	mg/L	1

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Environmental and Natural Resources Consulting and Analytical Services

DATE: 10/05/89

CTI LAB NO: L8911356
P. O. NO: N/A

To: CTI/Project No. 345
Beaver Lake

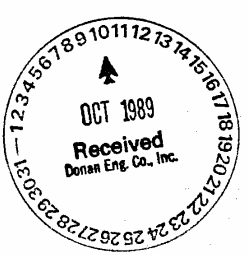
Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 4
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 3:00P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

Additional Parameters Reported-Previous Lab No. L8910591

PARAMETER	RESULTS	UNITS	DET'T LIMIT
pH	7.4	S U	N/A
Solids, Total Dissolved	58	mg/L	1



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DATE: 09/21/89

CTI LAB NO: L8910596
P. O. NO:

To: CTI/Project No. 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 5-1640
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 4:40P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

PARAMETER		RESULTS	UNITS	DET'T LIMIT
Nitrogen, Ammonia		0.03	mg/L	0.01
Nitrogen, Nitrate	<	0.05	mg/L	0.05
Nitrogen, Total Kjeldahl		1.3	mg/L	0.01
Phosphorus, Dissolved	<	0.01	mg/L as P	0.01
Phosphorus, Total		0.07	mg/L as P	0.01
Solids, Total Suspended		40	mg/L	1

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DATE: 10/05/89

CTI LAB NO: L8911361
P. O. NO: N/A

To: CTI/Project No. 345
Beaver Lake

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: Storm Sample No. 5
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 09/06/89
COLLECTION TIME: 4:40P
COLLECTED BY: Client
DATE RECEIVED: 09/07/89

Additional Parameters Reported-Previous Lab No. L8910596

PARAMETER	RESULTS	UNITS	DET'T LIMIT
pH	7.2	S U	N/A
Solids, Total Dissolved	136	mg/L	1

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: 09/12/89

CTI LAB NO: L8909424
P. O. NO: N/A

To: CTI/Job 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: CTI/BLI 1 0-4.5 ft.
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Comp
DATE OF COLLECTION: 08/09/89
COLLECTION TIME: 12:00P
COLLECTED BY: CTI
DATE RECEIVED: 08/11/89

PARAMETER		RESULTS	UNITS	DET'T LIMIT
EP Toxicity Arsenic	<	0.01	mg/L	0.01
EP Toxicity Barium	<	0.5	mg/L	0.5
EP Toxicity Cadmium	<	0.01	mg/L	0.01
EP Toxicity Chromium	<	0.05	mg/L	0.05
EP Toxicity Lead	<	0.05	mg/L	0.05
EP Toxicity Mercury	<	0.001	mg/L	0.001
EP Toxicity Selenium	<	0.01	mg/L	0.01
EP Toxicity Silver	<	0.03	mg/L	0.03
EP Toxicity: Herbicide, 2,4,5-TP Silvex	<	0.001	mg/L	0.001
EP Toxicity: Herbicide, 2,4-D	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Endrin	<	0.0001	mg/L	0.0001
EP Toxicity: Pesticide, Lindane	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Methoxychlor	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Toxaphene	<	0.001	mg/L	0.001
Nitrogen, Ammonia		90.9	mg/Kg TS	0.01
Nitrogen, Nitrate	<	0.5	mg/Kg TS	0.5
Nitrogen, Total Kjeldahl		1140	mg/Kg TS	0.01
Phosphorus, Dissolved	<	0.5	mg/Kg TS	0
Phosphorus, Total		284	mg/Kg TS	0.01
Solids, Total		67	%	0

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: 09/12/89

CTI LAB NO: L8909425
P. O. NO: N/A

To: CTI/Job 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: CTI/BLI 2 0-2 ft.
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Comp
DATE OF COLLECTION: 08/09/89
COLLECTION TIME: 12:00P
COLLECTED BY: CTI
DATE RECEIVED: 08/11/89

PARAMETER		RESULTS	UNITS	DET'T LIMIT
EP Toxicity Arsenic	<	0.01	mg/L	0.01
EP Toxicity Barium	<	0.5	mg/L	0.5
EP Toxicity Cadmium	<	0.01	mg/L	0.01
EP Toxicity Chromium	<	0.05	mg/L	0.05
EP Toxicity Lead	<	0.05	mg/L	0.05
EP Toxicity Mercury	<	0.001	mg/L	0.001
EP Toxicity Selenium	<	0.01	mg/L	0.01
EP Toxicity Silver	<	0.03	mg/L	0.03
EP Toxicity: Herbicide, 2,4,5-TP Silvex	<	0.001	mg/L	0.001
EP Toxicity: Herbicide, 2,4-D	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Endrin	<	0.0001	mg/L	0.0001
EP Toxicity: Pesticide, Lindane	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Methoxychlor	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Toxaphene	<	0.001	mg/L	0.001
Nitrogen, Ammonia		52.4	mg/Kg TS	0.01
Nitrogen, Nitrate	<	0.5	mg/Kg TS	0.5
Nitrogen, Total Kjeldahl		1060	mg/Kg TS	0.01
Phosphorus, Dissolved	<	0.5	mg/Kg TS	0
Phosphorus, Total		351	mg/Kg TS	0.01
Solids, Total		68	%	0

Route 3, Box 10
Grayson, KY 41143-9501
(606) 474-7891

2520 Regency Road
Lexington, KY 40503-2961
(606) 276-3506
FAX: Ext. 58

101 Jasper Street
Somerset, KY 42501-1201
(606) 679-3530

Edward G. Foree, Ph.D., P.E.

John S. Tapp, Ph.D., P.E., L.S.

COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: 09/12/89

CTI LAB NO: L8909426
P. O. NO: N/A

To: CTI/Job 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: CTI/BLI 3 0-4.3 ft.
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 08/09/89
COLLECTION TIME: 12:00P
COLLECTED BY: CTI
DATE RECEIVED: 08/11/89

PARAMETER		RESULTS	UNITS	DET'T LIMIT
EP Toxicity Arsenic	<	0.01	mg/L	0.01
EP Toxicity Barium	<	0.5	mg/L	0.5
EP Toxicity Cadmium	<	0.01	mg/L	0.01
EP Toxicity Chromium	<	0.05	mg/L	0.05
EP Toxicity Lead	<	0.05	mg/L	0.05
EP Toxicity Mercury	<	0.001	mg/L	0.001
EP Toxicity Selenium	<	0.01	mg/L	0.01
EP Toxicity Silver	<	0.03	mg/L	0.03
EP Toxicity: Herbicide, 2,4,5-TP Silvex	<	0.001	mg/L	0.001
EP Toxicity: Herbicide, 2,4-D	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Endrin	<	0.0001	mg/L	0.0001
EP Toxicity: Pesticide, Lindane	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Methoxychlor	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Toxaphene	<	0.001	mg/L	0.001
Nitrogen, Ammonia		209	mg/Kg TS	0.01
Nitrogen, Nitrate	<	0.5	mg/Kg TS	0.5
Nitrogen, Total Kjeldahl		2100	mg/Kg TS	0.01
Phosphorus, Dissolved	<	0.5	mg/Kg TS	0
Phosphorus, Total		466	mg/Kg TS	0.01
Solids, Total		56	%	0

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COMMONWEALTH TECHNOLOGY, INC.

Environmental and Natural Resources Consulting and Analytical Services

DATE: 09/12/89

CTI LAB NO: L8909427
P. O. NO: N/A

To: CTI/Job 345

Attn: Mike Tackett

REPORT ON TESTING OF SAMPLES

SAMPLE ID: CTI/BLI 4 0-3.3 ft.
SOURCE OF SAMPLE: Beaver Lake
SAMPLE TYPE: Grab
DATE OF COLLECTION: 08/09/89
COLLECTION TIME: 12:00P
COLLECTED BY: CTI
DATE RECEIVED: 08/11/89

PARAMETER		RESULTS	UNITS	DET'T LIMIT
EP Toxicity Arsenic	<	0.01	mg/L	0.01
EP Toxicity Barium	<	0.5	mg/L	0.5
EP Toxicity Cadmium	<	0.01	mg/L	0.01
EP Toxicity Chromium	<	0.05	mg/L	0.05
EP Toxicity Lead	<	0.05	mg/L	0.05
EP Toxicity Mercury	<	0.001	mg/L	0.001
EP Toxicity Selenium	<	0.01	mg/L	0.01
EP Toxicity Silver	<	0.03	mg/L	0.03
EP Toxicity: Herbicide, 2,4,5-TP Silvex	<	0.001	mg/L	0.001
EP Toxicity: Herbicide, 2,4-D	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Endrin	<	0.0001	mg/L	0.0001
EP Toxicity: Pesticide, Lindane	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Methoxychlor	<	0.001	mg/L	0.001
EP Toxicity: Pesticide, Toxaphene	<	0.001	mg/L	0.001
Nitrogen, Ammonia		89.9	mg/Kg TS	0.01
Nitrogen, Nitrate	<	0.5	mg/Kg TS	0.5
Nitrogen, Total Kjeldahl		1380	mg/Kg TS	0.01
Phosphorus, Dissolved	<	0.5	mg/Kg TS	0
Phosphorus, Total		320	mg/Kg TS	0.01
Solids, Total		64	%	0

Route 3, Box 10
Grayson, KY 41143-9501
(606) 474-7891

2520 Regency Road
Lexington, KY 40503-2961
(606) 276-3506
FAX: Ext. 53

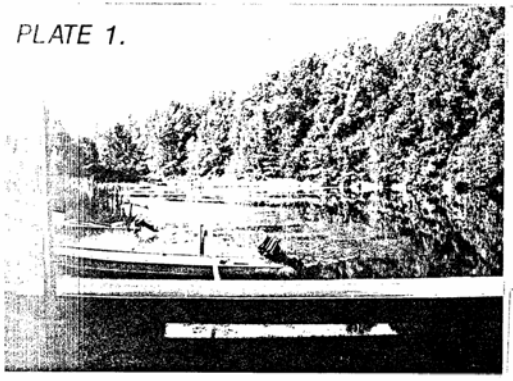
101 Jasper Street
Somerset, KY 42501-1203
(606) 679-3530

PHOTOGRAPHIC DOCUMENTATION

INDEX OF PHOTOGRAPHS
BEAVER CREEK RESERVOIR

PLATE	PHOTO #	DESCRIPTION
1	1	Third finger facing south from boat ramp.
	2	Cattail, naiads, and algae near boat ramp.
	3	Floating algae and submerged naiads.
	4	Cattail, bulrush, sedge, and naiads near boat ramp.
2	1	Fourth finger near delta, sedges and bulrushes in foreground.
	2	Continuation of photo #1.
	3	Looking south at fork of fingers 1 and 2.
	4	Shore erosion close-up from photo #3.
3	1	Recreational development along shoreline.
	2	Recreational development along shoreline.
	3	Public pit toilet at boat ramp.
	4	Abandoned school bus and trailer on city property.
4	1	Soybean field along tributary of first finger looking north-northeast.
	2	Outhouse and wash-out area along access road on city property.
	3	Abandoned fuel oil tank on city property.
	4	Abandoned 55-gallon drums on city property.

PLATE 1.

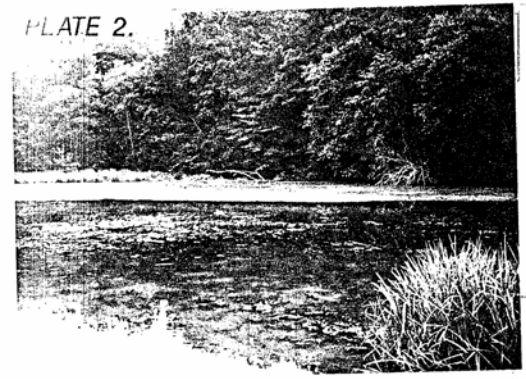


1

3

4

PLATE 2.



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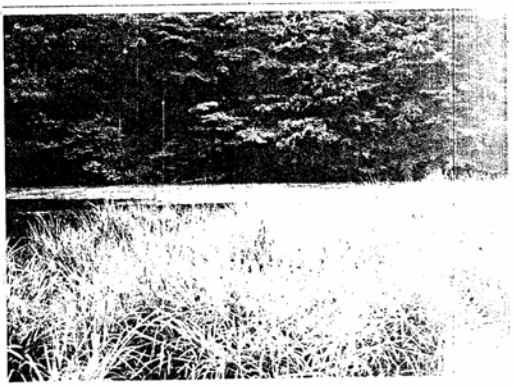

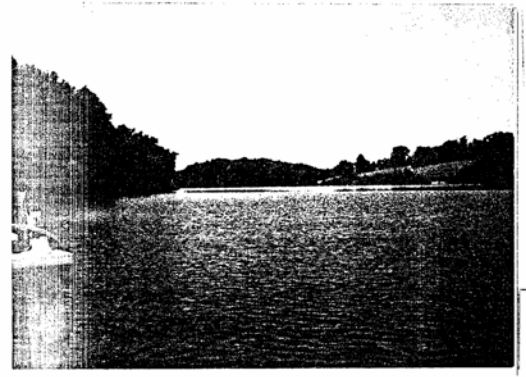

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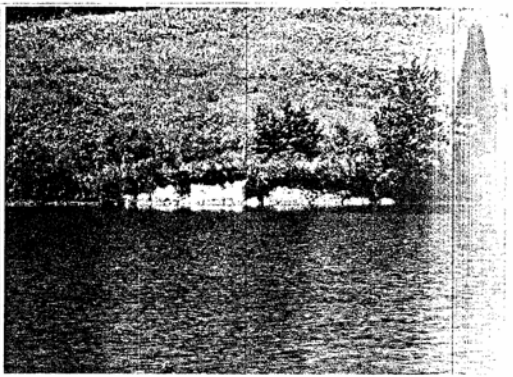
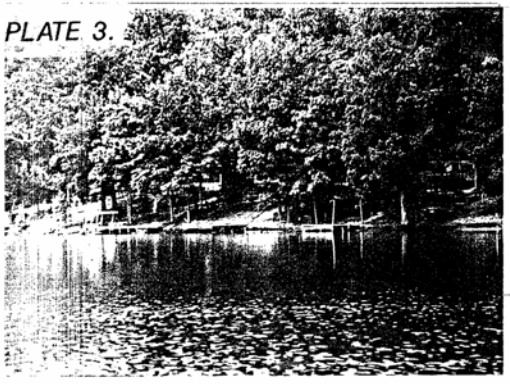


PLATE 3.



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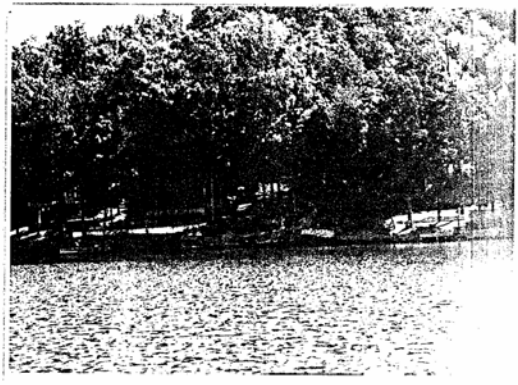

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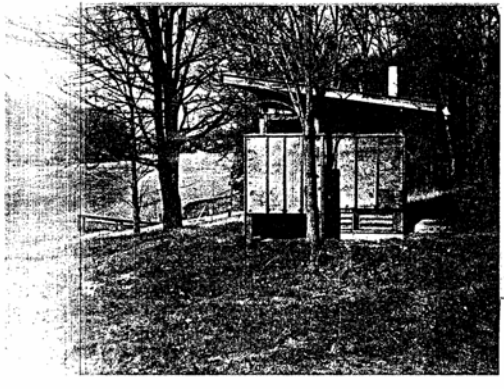

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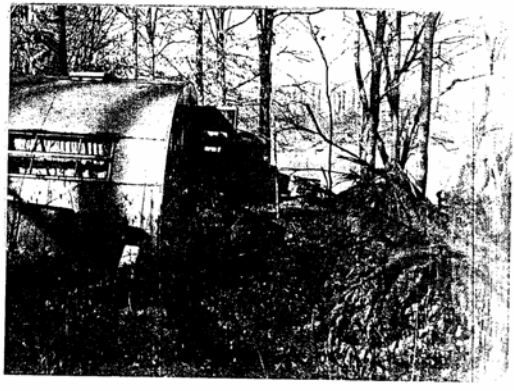


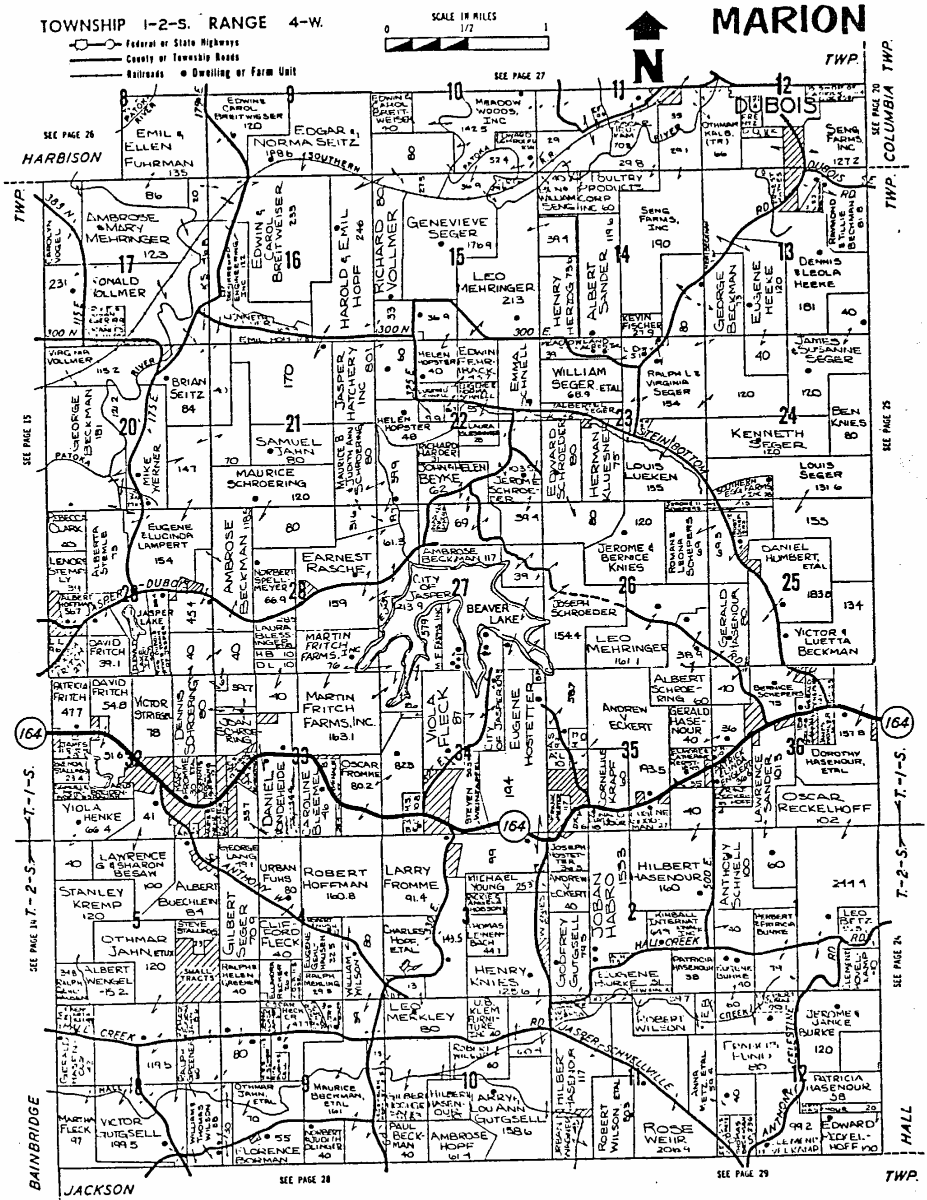
4

PLATE 4.

1

3

PLAT OF TOWNSHIP


TOWNSHIP 1-2-S. RANGE 4-W.
Federal or State Highways
County or Township Roads
Railroads
Dwelling or Farm Unit
SCALE IN MILES
0
1/2
1
N
MARION
TWP.
SEE PAGE 27
SEE PAGE 26
SEE PAGE 15
SEE PAGE 25
SEE PAGE 20
SEE PAGE 14
SEE PAGE 24
SEE PAGE 28
SEE PAGE 29
HARBISON
TWP.
COLUMBIA TWP.
BAINBRIDGE
JACKSON
HALL
TWP.
T.-1-S.
T.-2-S.
DUBOIS
CITY OF JASPER
BEAVER LAKE
JASPER LAKE
PATOKA RIVER
SOUTHERN
HALL CREEK
JASPER-SCHNELLVILLE RD
ANTHONY
164
EMIL & ELLEN FUHRMAN 135
EDWIN & CAROL BREITWIESER 120
EDGAR & NORMA SEITZ 198.6
MEADOW WOODS, INC 142.5
SENG FARMS, INC 127.2
POULTRY PRODUCTS
AMBROSE & MARY MEHRINGER 123
RONALD VOLLMER
EDWIN & CAROL BREITWEISER 233
HAROLD & EMIL HOPF 246
RICHARD VOLLMER
GENEVIEVE SEGER 176.9
LEO MEHRINGER 213
HENRY HERZOG 75
ALBERT SANDER
SENG FARMS, INC 190
GEORGE BECKMAN
EUGENE HEEKE 120
DENNIS & LEOLA HEEKE 181
JAMES & SUSANNE SEGER
BRIAN SEITZ 84
JASPER HATCHERY INC 80
HELEN HOPSTER
EDWIN FEHRIBACH
EMMA SCHNELL
WILLIAM SEGER ETAL 68.9
RALPH L & VIRGINIA SEGER 154
KENNETH SEGER 120
BEN KNIES 80
GEORGE BECKMAN 181
MIKE WERNER
SAMUEL JAHN 80
MAURICE SCHROERING 120
MAURICE B & JUDITH ANN SCHROERING
RICHARD HARDER
JOHN & HELEN BEYKE 62
JEROME SCHROEDER
EDWARD SCHROEDER 80
HERMAN KLUESNER
LOUIS LUEKEN 155
LOUIS SEGER 131.6
EUGENE & ELUCINDA LAMPERT 154
ALBERTA STEMLE
AMBROSE BECKMAN
EARNEST RASCHE
AMBROSE BECKMAN 117
JEROME & BERNICE KNIES
ROMANE & LEONA SCHEPERS
DANIEL HUMBERT, ETAL
NORBERT SPELLMEYER 66.9
LAURA BLESSINGER
MARTIN FRITCH FARMS, INC 76
JOSEPH SCHROEDER
LEO MEHRINGER 161.1
GERALD HASENOUR 80
VICTOR & LUETTA BECKMAN
DAVID FRITCH 39.1
PATRICIA FRITCH 47.7
DAVID FRITCH 54.8
VICTOR STRIEGEL 78
DENNIS SCHROERING
JOAN SCHROERING
MARTIN FRITCH FARMS, INC. 163.1
VIOLA FLECK 87
CITY OF JASPER
EUGENE HOSTETTER
ANDREW ECKERT
ALBERT SCHROERING 60
GERALD HASENOUR 40
BERNICE SCHEPERS
DOROTHY HASENOUR, ETAL
VIOLA HENKE 66.4
DANIEL VONDERHEIDE
CAROLINE BLEEMEL
OSCAR FROMME 80.2
STEVEN WEINZAPFEL
CORNELIUS KRAPF
LAWRENCE SANDER
OSCAR RECKELHOFF 102
LAWRENCE G & SHARON BESAW
STANLEY KREMP 120
ALBERT BUECHLEIN 84
GEORGE LANG
URBAN FUHS 80
ROBERT HOFFMAN 160.8
LARRY FROMME 91.4
MICHAEL YOUNG 253
ANDREW ECKERT
JOBAN HABRO 155.3
HILBERT HASENOUR 160
ANTHONY SCHNELL
OTHMAR JAHN, ETUX 120
ALBERT WENGEL
GILBERT SEGER
CLIFFORD FLECK 40
STEVE STALLINGS
WILLIAM WILSON
CHARLES HOPF, ETAL
THOMAS LEINENBACH
HENRY KNIES 125.6
GODFREY GUTGSELL
EUGENE BURKE
KIMBALL INTERNAT
PATRICIA HASENOUR 38
RALPH & HELEN GREENER
LEO MERKLEY 80
U.B. KLEM FURNITURE
ROBERT WILSON
JEROME & JANICE BURKE 120
FREDERICK FUHS
SMALL TRACTS
VICTOR GUTGSELL 199.5
MARTHA FLECK 97
OTHMAR JAHN, ETAL
MAURICE BECKMAN, ETAL 161
FLORENCE BORMAN
PAUL BECKMAN 40
AMBROSE HOPF 61.4
LARRY & LOU ANN GUTGSELL 158.6
HILBERT HASENOUR 117
ROBERT WILSON, ETAL
ROSE WEHR 206.4
ANNA METZ, ETAL
PATRICIA HASENOUR 58
EDWARD HICKELHOFF
CELESTINE

WATER/SEWAGE SURVEY RESULTS

BEAVER CREEK RESERVOIR WATER AND SEWAGE SURVEY

SUMMARY

Out of 162 surveys sent out to recreational lot leasers from the City of Jasper, Fritch Farms, Inc. and Mr. Beckman, 130 were returned with 1 unanswered as of November 28, 1989. The 129 answered surveys total a 79.6 percent response. Responses by leasee are: City of Jasper - 85%; Mr. Beckman - 85%; Fritch Farms, Inc. - 74%. Based on the 129 responses, 99 percent of the lot leasers are temporary residents, from minimal usage (2 or 3 weekends per year) to weekend usage through the year along with the summer vacation period. Of the 5 responses that were reported as year-round users, only 2 are believed to permanently reside on the lake based on reported water consumption. These 2 have city water with 1 consuming 10,000 gallons with a septic system and 1 consuming a questionable 20,000 gallons with a holding tank. Lots that are permanently resided on along the lake were previously estimated at 6 by Mike Oeding, Superintendent of the Gas and Water Utility for the City of Jasper.

The water supply for the leasers is predominantly from outside sources, carried into their residences (68 percent). One additional leaser has water trucked in and consumes 1,000 gallons per year with a septic system. Those on the Dubois Water Utility line total 27 percent, and the remaining 3 percent is composed of 4 responses reporting Beaver Creek Reservoir as their water supply.

For those on the Dubois Water Utility line, 31 percent reported their usage as minimal or did not reply at all. Those reporting consumption up to 3000 gallons totalled 48 percent with holding tanks the predominant system (69 percent) for these users. For those 7 consuming over 3000 gallons (21 percent), 3 consume approximately 10,000 gallons and 1 consumes an estimated 20,000 gallons with holding tanks the predominant method of disposal.

Concerning sewage systems, 58 percent of the responses keyed outhouses as their method of sewage disposal. An additional 5 percent report outhouse/holding tank combinations. Holding tanks comprise 20 percent; 4 percent have septic systems; 4 percent have portable toilets, and 9 percent report having no system with some making note that they use their neighbors' facilities.

In general, the average lot leaser at Beaver Creek Reservoir resides through the summer vacation period and weekends throughout the year (49 percent), carries in water (68 percent) and has an outhouse (58 percent). However, of the remaining 33 leasers (20 percent) that have not responded, it is questionable how many characterize their usage as year-round or permanent and have city water.

BEAVER CREEK RESERVOIR WATER AND SEWAGE SURVEY ANALYSIS

1. USAGE

	MINIMAL	WEEKENDS	WEEKENDS/ SUMMER	SUMMER	YEAR ROUND
Totals	2	40	63	23	2
Percentages	1%	31%	49%	18%	1%

2. WATER SUPPLY

	WELL	BEAVER CREEK RESERVOIR	DUBOIS WATER UTILITY	CARRIED IN	TRUCKED IN
Totals	1	4	35	88	1
Percentages	1%	3%	27%	68%	1%

3. DUBOIS WATER UTILITY CONSUMPTION

	NO ANSWER/ MINIMAL	0-1000 GAL	1000-3000 GAL	3000+ GAL	10,000 GAL	20,000 GAL
Totals	11	10	7	3	3	1
Percentages	31%	28%	20%	9%	9%	3%

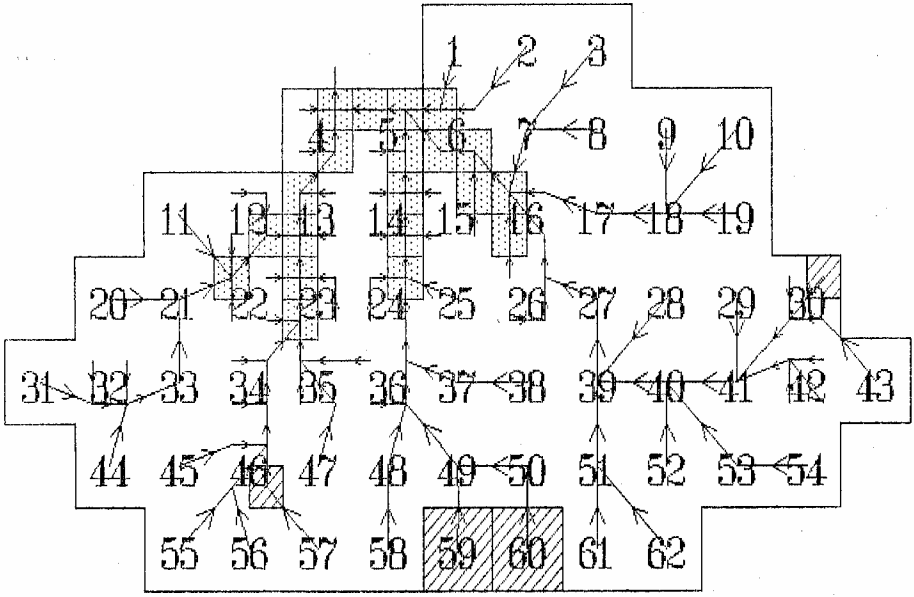
4. SEWAGE DISPOSAL SYSTEM

	OUTHOUSE	OUTHOUSE/ TANK	HOLDING TANK	SEPTIC TANK	RV/ PORTA-POT	NONE
Totals	75	7	26	5	5	11
Percentages	58%	5%	20%	4%	4%	9%

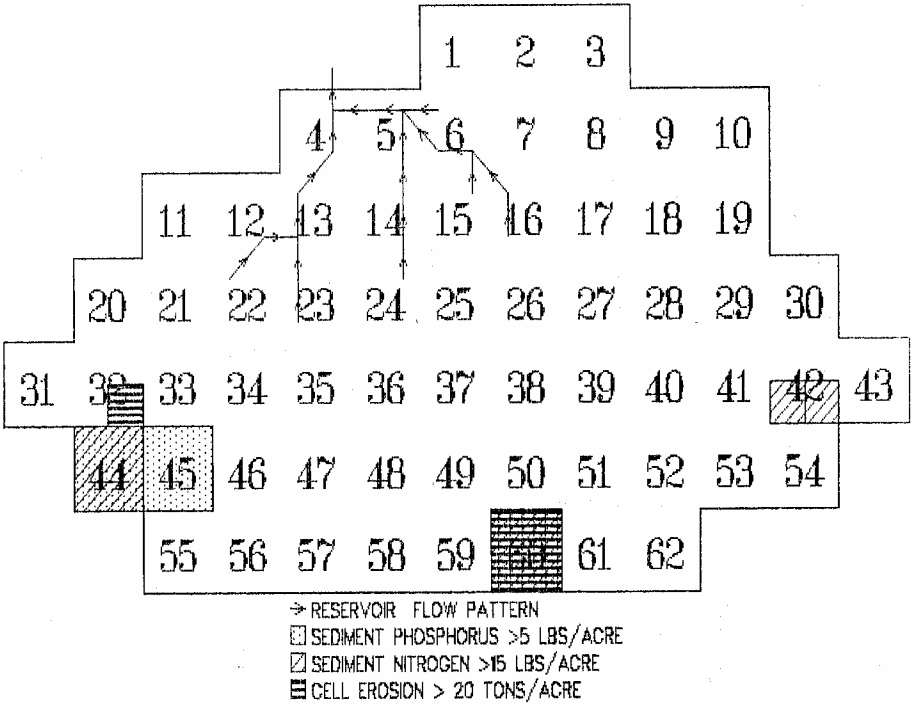
Date: November 29, 1989

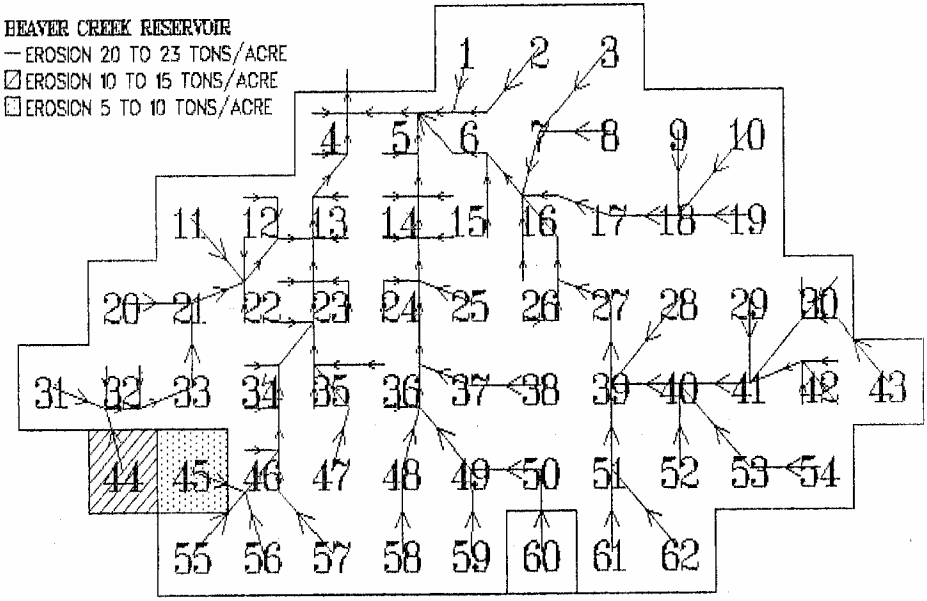
AgNPS COMPUTER MODEL

BEAVER CREEK RESERVOIR



BEAVER CREEK RESERVOIR




BEAVER CREEK RESERVOIR
— EROSION 20 TO 23 TONS/ACRE
EROSION 10 TO 15 TONS/ACRE
EROSION 5 TO 10 TONS/ACRE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
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19
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47
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51
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56
57
58
59
60
61
62

CURRENT CONDITIONS

Watershed Summary

Watershed Studied	BEAVER CREEK RESERVOIR	
The area of the watershed is	2480	acres
The area of each cell is	40.00	acres
The characteristic storm precipitation is	5.20	inches
The storm energy-intensity value is	168	

Values at the Watershed Outlet

Cell number	4 200	
Runoff volume	2.8	inches
Peak runoff rate	1408	cfs
Total Nitrogen in sediment	0.29	lbs/acre
Total soluble Nitrogen in runoff	0.78	lbs/acre
Soluble Nitrogen concentration in runoff	1.23	ppm
Total Phosphorus in sediment	0.15	lbs/acre
Total soluble Phosphorus in runoff	0.09	lbs/acre
Soluble Phosphorus concentration in runoff	0.14	ppm
Total soluble chemical oxygen demand	43.20	lbs/acre
Soluble chemical oxygen demand concentration in runoff	68	ppm

Display Report On Screen

Esc-Toggle Menu F1-Help F2-Image F5-Print F10-Menu

Sediment Analysis

Particle type	Area Weighted Erosion Upland (t/a)	Area Weighted Erosion Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Mean Concentration (ppm)	Area Weighted Yield (t/a)	Yield (tons)
CLAY	0.10	0.00	42	19	127.50	0.04	100.6
SILT	0.15	0.00	0	0	1.13	0.00	0.9
SAGG	0.97	0.00	0	0	1.16	0.00	0.9
LAGG	0.60	0.00	0	0	3.89	0.00	3.1
SAND	0.12	0.00	0	0	1.22	0.00	1.0
TOTAL	1.93	0.00	2	1	134.90	0.04	106.4

Display Report On Screen

Esc-Toggle Menu F1-Help F2-Image F5-Print F10-Menu

Condensed Soil Loss

Cell Num	Div	Drainage Area (acres)	RUNOFF Volume (in.)	Generated Peak Rate Above (%)	Rate (cfs)	Cell Erosion (t/a)	SEDIMENT Generated Above (tons)	Within (tons)	Yield (tons)	Depo (%)
14	300	10	3.26	0.0	107	0.61	0.00	6.15	4.67	24
14	400	460	5.20	95.9	386	0.00	70.07	0.00	48.22	31
15	100	10	3.26	0.0	114	1.18	0.00	11.83	8.87	25
15	200	20	5.20	32.7	73	0.00	9.65	0.00	0.70	93
15	300	10	3.26	0.0	112	1.23	0.00	12.27	9.16	25
15	400	10	2.52	0.0	91	1.32	0.00	13.22	9.65	27
16	100	1000	5.20	98.0	674	0.00	481.18	0.00	59.58	88
16	200	210	2.44	95.5	511	1.18	107.45	11.78	102.15	14
16	300	20	5.20	31.9	72	0.00	7.89	0.00	0.61	92
16	400	640	2.44	98.5	1121	2.63	355.19	26.34	347.10	9
12	400	340	5.20	94.6	326	0.00	61.18	0.00	43.54	29
16	100	1000	5.20	98.0	674	0.00	481.18	0.00	59.58	88
16	200	210	2.44	95.5	511	1.18	107.45	11.78	102.15	14

Display Report On Screen

Esc-Toggle Menu F1-Help F2-Image F5-Print F10-Menu

Condensed Soil Loss

Cell Num	Div	Drainage Area (acres)	RUNOFF Volume (in.)	Generated Peak Rate Above (%)	Rate (cfs)	Cell Erosion (t/a)	SEDIMENT Generated Above (tons)	Within (tons)	Yield (tons)	Depo (%)
34	200	240	2.44	96.2	351	0.55	172.58	5.48	143.57	19
34	300	10	3.26	0.0	101	9.23	0.00	92.33	63.21	32
34	400	220	2.44	95.9	358	1.47	195.35	14.69	166.59	21
35	100	90	2.44	89.1	176	1.59	39.94	15.85	37.74	32
35	200	20	2.44	50.9	95	0.27	3.95	2.63	5.03	24
35	300	10	2.52	0.0	65	1.47	0.00	14.69	9.40	36
35	400	50	2.44	80.5	138	1.03	30.15	10.35	25.50	37
36	100	10	2.52	0.0	81	0.58	0.00	5.78	3.95	32
36	200	350	2.44	97.3	523	0.62	454.19	6.18	395.01	14
36	300	10	2.52	0.0	89	1.02	0.00	10.24	7.08	31
22	100	310	5.20	94.0	318	0.00	545.86	0.00	53.20	90
24	400	360	2.44	97.4	489	1.53	395.01	15.34	351.20	14
26	200	630	2.44	98.5	710	1.28	386.36	12.79	355.19	11

Display Report On Screen

Esc-Toggle Menu F1-Help F2-Image F5-Print F10-Menu

Nutrient Analysis

N I T R O G E N

Sediment — Water Soluble

Cell Num	Div	Drainage Area (acres)	Within Cell (lbs/a)	Cell Outlet (lbs/a)	Within Cell (lbs/a)	Cell Outlet (lbs/a)	Conc (ppm)
14	300	10	2.14	1.72	0.63	0.63	1
14	400	460	0.00	0.60	0.94	1.15	2
15	100	10	3.62	2.87	0.63	0.63	1
15	200	20	0.00	0.25	0.94	0.71	1
15	300	10	3.73	2.95	0.63	0.63	1
15	400	10	3.96	3.07	0.48	0.48	1
16	100	1000	0.00	0.38	0.94	0.61	1
16	200	210	3.61	1.78	0.46	0.61	1
16	300	20	0.00	0.22	0.94	0.70	1
16	400	640	6.87	1.94	0.46	0.62	1
12	400	340	0.00	0.70	0.94	1.10	2
16	100	1000	0.00	0.38	0.94	0.61	1
23	200	20	4.93	3.68	0.46	0.46	1
23	300	350	0.00	0.45	0.94	0.60	1
23	400	10	6.03	4.67	0.46	0.46	1
24	100	20	3.35	2.09	0.46	0.47	1
24	200	430	0.00	0.71	0.94	1.18	2
24	300	10	2.53	1.88	0.48	0.48	1
24	400	360	4.46	3.10	0.46	1.30	2
25	000	40	3.35	2.55	0.46	0.46	1
26	100	10	3.36	2.62	0.46	0.46	1
26	200	630	3.85	2.00	0.46	0.62	1
24	400	360	4.46	3.10	0.46	1.30	2
22	100	310	0.00	0.89	0.94	1.15	2
34	100	10	2.84	2.10	0.48	0.48	1
34	200	240	1.96	2.10	0.46	0.64	1
34	300	10	18.73	13.83	0.63	0.63	1
34	400	220	4.30	2.53	0.46	0.66	1
35	100	90	4.57	1.58	0.46	0.47	1
35	200	20	1.10	1.05	0.46	0.47	1
35	300	10	4.30	3.01	0.48	0.48	1
35	400	50	3.25	1.85	0.46	0.48	1
36	100	10	2.04	1.50	0.48	0.48	1
36	200	350	2.15	3.49	0.46	1.33	2
34	200	240	1.96	2.10	0.46	0.64	1
34	400	220	4.30	2.53	0.46	0.66	1

Display Report On Screen

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Nutrient Analysis

P H O S P H O R U S

Cell Num	Div	Drainage Area (acres)	Sediment Within Cell (lbs/a)	Sediment Cell Outlet (lbs/a)	Water Soluble Within Cell (lbs/a)	Water Soluble Cell Outlet (lbs/a)	Conc (ppm)
14	300	10	1.07	0.86	0.04	0.04	0
14	400	460	0.00	0.30	0.03	0.17	0
15	100	10	1.81	1.44	0.04	0.04	0
15	200	20	0.00	0.12	0.03	0.03	0
15	300	10	1.86	1.47	0.04	0.04	0
15	400	10	1.98	1.54	0.03	0.03	0
16	100	1000	0.00	0.19	0.03	0.06	0
16	200	210	1.80	0.89	0.03	0.06	0
16	300	20	0.00	0.11	0.02	0.03	0
16	400	640	3.43	0.97	0.03	0.06	0
12	400	340	0.00	0.35	0.03	0.16	0
16	100	1000	0.00	0.19	0.03	0.06	0
23	200	20	2.47	1.84	0.03	0.03	0
23	300	350	0.00	0.22	0.02	0.05	0
23	400	10	3.02	2.33	0.03	0.03	0
24	100	20	1.67	1.05	0.03	0.03	0
24	200	430	0.00	0.36	0.02	0.18	0
24	300	10	1.27	0.94	0.03	0.03	0
24	400	360	2.23	1.55	0.03	0.20	0
25	000	40	1.68	1.27	0.03	0.03	0
26	100	10	1.68	1.31	0.03	0.03	0
26	200	630	1.93	1.00	0.03	0.06	0
22	100	310	0.00	0.44	0.03	0.18	0
24	400	360	2.23	1.55	0.03	0.20	0
34	100	10	1.42	1.05	0.03	0.03	0
34	200	240	0.98	1.05	0.03	0.06	0
34	300	10	9.36	6.92	0.04	0.04	0
34	400	220	2.15	1.27	0.03	0.07	0
35	100	90	2.29	0.79	0.03	0.03	0
35	200	20	0.55	0.52	0.03	0.03	0
35	300	10	2.15	1.51	0.03	0.03	0
35	400	50	1.63	0.92	0.03	0.03	0
36	100	10	1.02	0.75	0.03	0.03	0
36	200	350	1.08	1.74	0.03	0.21	0
34	200	240	0.98	1.05	0.03	0.06	0
34	400	220	2.15	1.27	0.03	0.07	0

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Feedlot Analysis

Cell # 50 200

Nitrogen concentration (ppm)	1.874
Phosphorus concentration (ppm)	0.775
COD concentration (ppm)	21.145
Nitrogen mass (lbs)	3.547
Phosphorus mass (lbs)	1.467
COD mass (lbs)	40.006
Animal feedlot rating number	0

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Feedlot Analysis

Cell # 46 400

Nitrogen concentration (ppm)	2.946
Phosphorus concentration (ppm)	1.369
COD concentration (ppm)	37.883
Nitrogen mass (lbs)	2.062
Phosphorus mass (lbs)	0.959
COD mass (lbs)	26.520
Animal feedlot rating number	0

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Feedlot Analysis

Cell # 59 000

Nitrogen concentration (ppm)	4.050
Phosphorus concentration (ppm)	0.706
COD concentration (ppm)	66.375
Nitrogen mass (lbs)	92.647
Phosphorus mass (lbs)	16.139
COD mass (lbs)	1518.387

Animal feedlot rating number 39

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Feedlot Analysis

Cell # 60 000

Nitrogen concentration (ppm)	2.589
Phosphorus concentration (ppm)	0.610
COD concentration (ppm)	50.855
Nitrogen mass (lbs)	76.452
Phosphorus mass (lbs)	18.003
COD mass (lbs)	1501.443

Animal feedlot rating number 39

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TREATMENT 1

Watershed Summary

Watershed Studied	BEAVER CREEK RESERVOIR
The area of the watershed is	2100 acres
The area of each cell is	40.00 acres
The characteristic storm precipitation is	5.20 inches
The storm energy-intensity value is	168

Values at the Watershed Outlet

Cell number	4 200
Runoff volume	2.7 inches
Peak runoff rate	1378 cfs
Total Nitrogen in sediment	0.16 lbs/acre
Total soluble Nitrogen in runoff	0.65 lbs/acre
Soluble Nitrogen concentration in runoff	1.04 ppm
Total Phosphorus in sediment	0.05 lbs/acre
Total soluble Phosphorus in runoff	0.06 lbs/acre
Soluble Phosphorus concentration in runoff	0.05 ppm
Total soluble chemical oxygen demand	38.50 lbs/acre
Soluble chemical oxygen demand concentration in runoff	62 ppm

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Sediment Analysis

Particle type	Area Weighted Upland Erosion (t/a)	Area Weighted Channel Erosion (t/a)	Delivery Ratio (%)	Enrichment Ratio	Mean Concentration (ppm)	Area Weighted Yield (t/a)	Yield (tons)
CLAY	0.05	0.00	44	18	58.75	0.02	53.5
SILT	0.08	0.00	0	0	1.13	0.00	0.9
SAND	0.49	0.00	0	0	1.17	0.00	0.7
LAGG	0.30	0.00	0	0	3.33	0.00	3.0
SAND	0.06	0.00	1	0	1.23	0.00	1.0
TOTAL	0.97	0.00	2	1	77.21	0.02	59.5

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TREATMENT 2

Watershed Studied BEAVER CREEK RESERVOIR

The area of the watershed is	2480	acres
The area of each cell is	40.00	acres
The characteristic storm precipitation is	5.20	inches
The storm energy-intensity value is	160	

Values at the Watershed Outlet

Cell number	4	200
Runoff volume	2.47	inches
Peak runoff rate	1378	cfs
Total Nitrogen in sediment	0.15	lbs/acre
Total soluble Nitrogen in runoff	0.63	lbs/acre
Soluble Nitrogen concentration in runoff	1.01	ppm
Total Phosphorus in sediment	0.00	lbs/acre
Total soluble Phosphorus in runoff	0.05	lbs/acre
Soluble Phosphorus concentration in runoff	0.09	ppm
Total soluble chemical oxygen demand	38.23	lbs/acre
Soluble chemical oxygen demand concentration in runoff	61	ppm

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Sediment Analysis

Particle type	Area Weighted Erosion Upland (t/a)	Area Weighted Erosion Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Mean Concentration (ppm)	Area Weighted Yield (t/a)	Yield (tons)
CLAY	0.05	0.00	44	18	59.74	0.02	53.8
SILT	0.00	0.00	0	0	1.13	0.00	0.9
SAND	0.25	0.00	6	0	1.17	0.00	0.9
LAGG	0.00	0.00	0	0	3.63	0.00	3.0
SAND	0.06	0.00	1	0	1.23	0.00	1.0
TOTAL	0.97	0.00	2	1	77.21	0.02	59.5

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TREATMENT 2

Feedlot Analysis

Cell # 59 000

Nitrogen concentration (ppm)	2.704
Phosphorus concentration (ppm)	0.632
COD concentration (ppm)	51.294
Nitrogen mass (lbs)	61.862
Phosphorus mass (lbs)	14.456
COD mass (lbs)	1173.407
Animal feedlot rating number	35

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Feedlot Analysis

Cell # 60 000

Nitrogen concentration (ppm)	2.589
Phosphorus concentration (ppm)	0.610
COD concentration (ppm)	50.855
Nitrogen mass (lbs)	59.236
Phosphorus mass (lbs)	13.949
COD mass (lbs)	1163.347
Animal feedlot rating number	35

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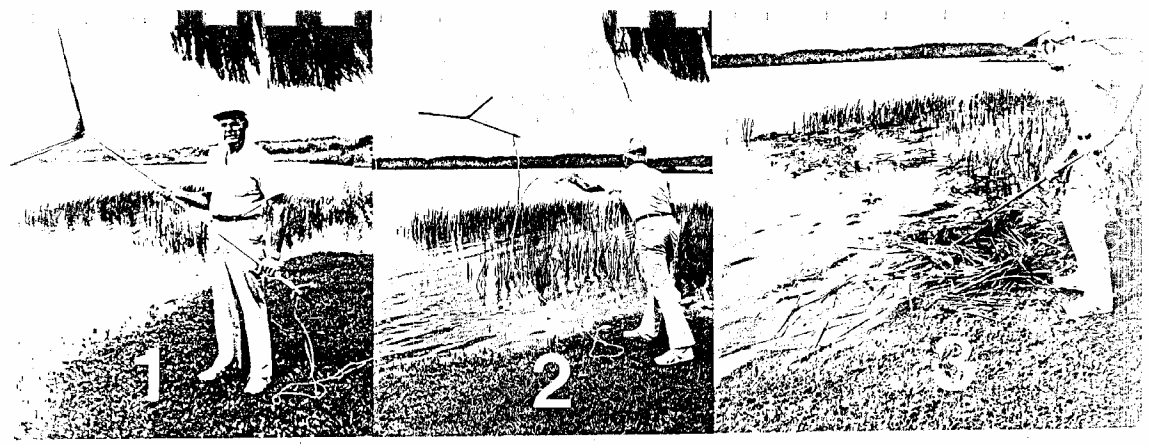
MISCELLANEOUS INFORMATION

NOTICE OF DISCLAIMER: Wherein one or more certain materials, trade names, or equipment of certain manufacture are referenced or enclosed, it is done for the express purpose of providing information on current equipment and technology on the market, and not with the purpose or intent of endorsement nor the exclusion of comparable products.



HANDY MARKETING CO.

Dear Friend

If you have a water weed problem, you already know what a job it is keeping the weed growth under control. Water weeds can greatly affect the use of your water property by inhibiting swimming, fishing and boating. Uncontrolled water weeds can also be an unsightly mess.

The AQUA WEED CUTTER will not only solve your water weed problems, but also help you do your part in preserving our nation's most valuable resource. If for any reason you are not satisfied in 30 days with the operation of the AQUA WEED CUTTER, return it to wherever you purchased it for a full refund. This is a no risk offer on your part.

The AQUA WEED CUTTER is manufactured with the highest degree of workmanship and the highest quality of materials. The AQUA WEED CUTTER is 100% manufactured in the United States. Zinc plating and the stainless steel resharpenable blades offer a high degree of corrosion resistance. We are so sure of the quality of materials and workmanship that goes into each AQUA WEED CUTTER that we have recently extended the limited warranty period from 90 days to 1 year.

Sincerely,

Don Breckenridge

Don Breckenridge,
President

SATISFIED CUSTOMERS

"Does a fantastic job - I figured I cleared more weeds in two hours than I've previously been able to in a whole summer."
-South Haven, MI

"My friend brought his AWC over to my house and I tried it. I thought it was great and I ordered one. The AWC is effective and easy to use."
-Webster, WI

"I like it very much. It does a very good job. I had to put a longer rope on it because I can throw it farther than the rope would permit. It's nice to be able to cut weeds without getting wet, especially when the water is cold."
-Aitkin, MN

"Gentlemen, I wish to inform you that your AQUA WEED CUTTER does a very good job and I am pleased. Several of the neighbors have also ordered them."
-Gowen, MI

"We have tried the AQUA WEED CUTTER and find it does an excellent job of cleaning the weeds in our beach, along the long pier and boat docks. We are very satisfied with the product and would recommend it to anyone who has a need."
-Claypool, IN

BEACHES • PONDS & SMALL LAKES CAN BE WEED FREE! SAFE, EASY-TO-USE AWC HELPS TO CONTROL WATER WEEDS

- Cuts a 48" path up to 20' deep (without operator getting wet!)
- Just throw it out and pull it in from **Any Dock or Shore!**

Stainless Steel Resharpenable Blades!
30-DAY MONEY BACK GUARANTEE!!

WEED FREE BEACHES With the AQUA WEED CUTTER

THE AQUA WEED CUTTER IS DESIGNED TO MAKE IT EASY FOR EVERYONE TO USE.

WOULDN'T YOU LIKE A WEED FREE BEACH?

AQUA WEED CUTTER NOW AVAILABLE AT:

Distributed by HANDY MARKETING CO.
4394 AIRWEST, S.E. • GRAND RAPIDS, MI 49508
(616) 698-8335

Fill out this Handy order form and return in the enclosed envelope to:

HANDY MARKETING COMPANY
394 Airwest St., S.E.
Grand Rapids, MI 49508
616-698-8335

TOLL-FREE ORDER NUMBER:
8am - 5pm
1-800-635-9645

Name _____

Address _____

City _____ State _____

Zip _____ Phone ( ) _____

MODEL #	DESCRIPTION	QUANTITY	PRICE EA.	TOTAL
AWC-4/KS 1	Aqua Weed Cutter w/ Super Sharpener		$84.95	
AWR-1	Aqua Weed Rake		$89.95	

Subtotal	
C.O.D. fee	
sales tax*	
Grand Total	

*Michigan residents add 4% sales tax

PRICES SUBJECT TO CHANGE WITHOUT NOTICE

Method of Payment
(check one box)

- ☐ Payment Enclosed
  Check or money order made payable to HMC
- ☐ C.O.D. add $3.00
- ☐ Visa or MasterCard

30-day money back guarante
1-year limited warranty
shipping and handling includ

☐ Please send details on Dealerships

Card #

Expiration Date _____ Signature _____

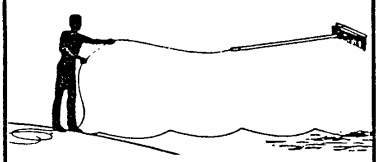
AQUA WEED RAKE™

Removes Cut Weeds and Algae from Lakes and Ponds

- Fun and Easy because it's LIGHT WEIGHT!

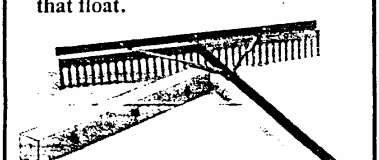
Just Throw it out and Rake in the weeds

Throw from Dock or Shore

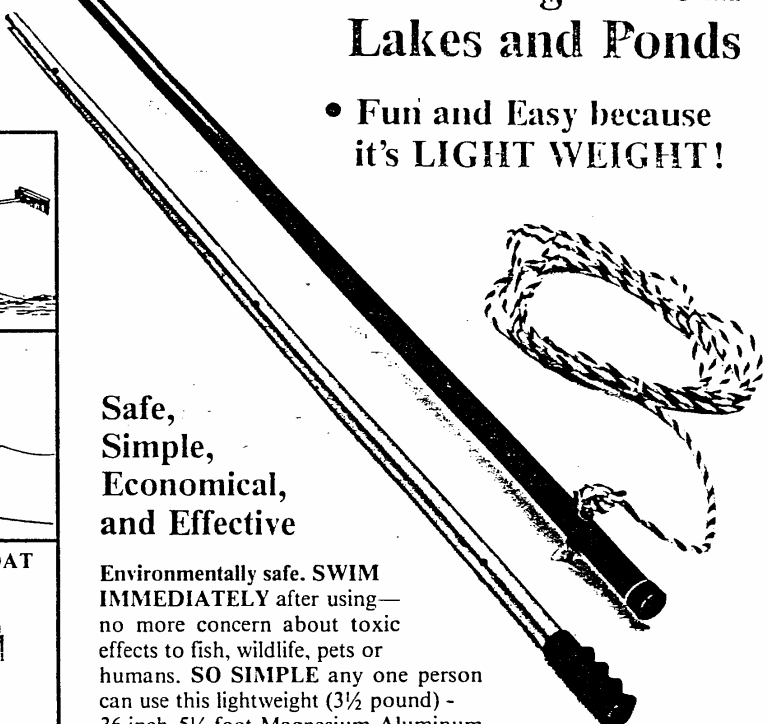


Pull to shore while wading

ATTACHABLE FOAM FLOAT for removing Weeds & Algae that float.



Unwanted water weeds make excellent garden Fertilizer



Safe, Simple, Economical, and Effective

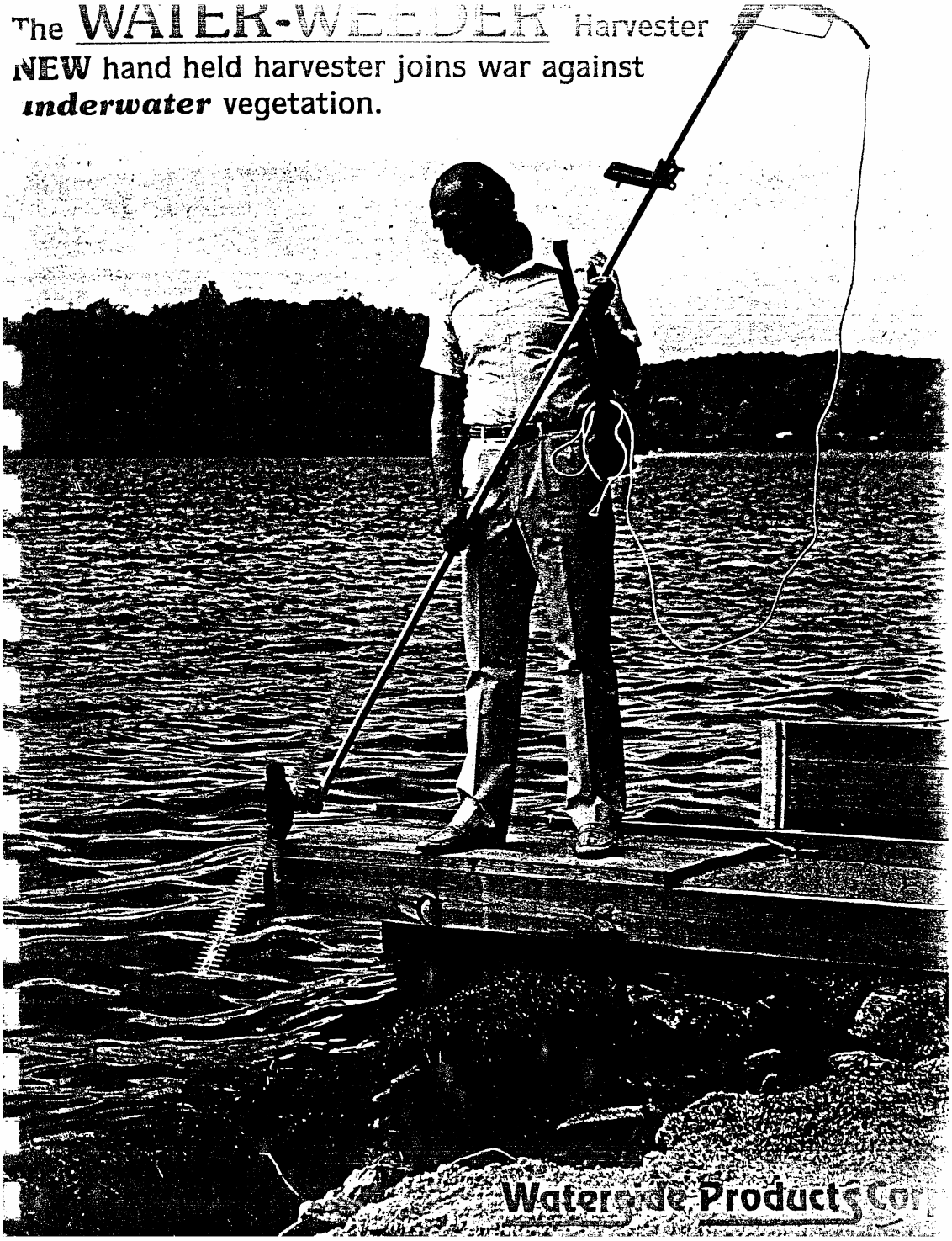
Environmentally safe. SWIM IMMEDIATELY after using—no more concern about toxic effects to fish, wildlife, pets or humans. **SO SIMPLE** any one person can use this lightweight (3½ pound) - 36 inch-5½ foot Magnesium Aluminum Rake. Adjustable extension (6′ to 10′) allows for removing weeds and debris from lake bottoms. **ECONOMICAL** because it provides many years of weed removal for less than the cost of chemical treatments. Ideal for fast and easy "Shoreline clean-up" or "Sand Raking" beaches or gardens. The Attachable Float makes the rake **MORE EFFECTIVE** for removing weeds that float.

- What could be a better companion tool for "Aqua Weed Cutter" owners?

HMc Dist. by HANDY MARKETING Co. • 4394 Airwest, S.E. • Grand Rapids, MI 49508 • PH 616 • 698-8335

The WATER-WEEDER Harvester

NEW hand held harvester joins war against ***underwater*** vegetation.



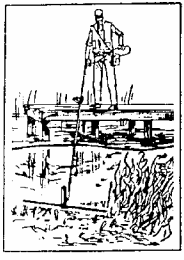
Operated easily from a boat, from shore or by wading in shallow water. . . .

"Unbelievable! Why didn't anyone think of this sooner."
J.T. Mahopac, NY

"My guests can finally swim in front of our house, what a great improvement."
J.F. San Jose, CA

"Works just like an ordinary hedge trimmer."
A.F. Portsville, PA

Attach to virtually any boat with handy clamp supplied.



Light weight and easily handled from shore, dock or bulkhead.

Wade in from shore just like mowing your lawn.

"The Amazing Underwater"

WATER-WEEDER™

Full One Year Guarantee

Boat Clamp

A custom designed clamp is supplied, making it a simple process to attach the harvester to the side of a boat.

Steering Grip

A special handle which is movable along the length of the shaft helps guide the harvester around the most aggravating obstacles.

Adjustable Shaft

Made of heavy gauge aluminum, in two quick connect 4 ft. sections. Shaft allows for cutting up to eight feet below the surface of the water. *Optional* four foot section extends the cutting depth to twelve feet.

Motor

Heavy Duty 12 Volt motor provides the power to operate the oscillating blades. Built-in clutch mechanism as well as the fuse circuitry protects against motor burnout. Specially designed reduction mechanism delivers extra power. Guaranteed sealed and watertight.

Cutting Blades

Corrosion free Stainless Steel cutting blades. These special blades will cut a four foot wide swath with the same ease as passing a hot knife through butter. Anyone familiar with a standard hedge trimmer will quickly identify with the harvesters cutting ability. Blade cuts in both directions.

Pistol Grip Control Hand

Special watertight trigger, on-off controls with "lock on." Has built in buzzer and indicator light to signal any interruption in cutting blade operation. Switch also reverses motion of blades for freeing any snags.

Battery Powered

12 ft. thoroughly insulated cord leads to either your boat battery, boat cigarette lighter, or our special rechargeable battery pack. (sold *separately*).
Safety: Twelve volt power provides a safe form of energy readily used in and around water.

Special Swivel Joints

Unique elbows and joints allow the blades to move freely in many directions, avoiding interruptions caused by unseen obstacles.

Bottom Roller

Roller attached to underside of motor which allows blades to follow contour of lake bottom.

Net

30 ft. Collection net with 15 floatation buoys and 15 ft. of anchor line INCLUDED!

$299.99

Plus Freight and Handling

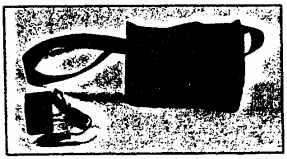
"Less than a good lawn mower!"

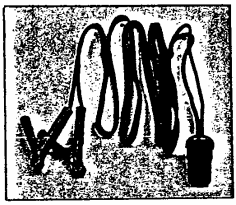
Accessories:

Twelve Volt Rechargeable Power Pack.

Will provide over one hour of continuous operation. Lightweight with custom carrying case. Recharges at least 500 times at ordinary household outlet. Charger included.

$79.99





Boat or Car Battery Adapter

Two foot long cable to quickly connect Harvester to your boat or car battery.

$7.99

Four Foot Shaft Extension

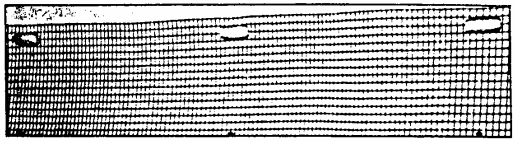
Provides the option of extending the cutting depth of the Harvester from eight feet to twelve feet.

$24.99

Specially Designed Collection Net

Included with your order!

30ft. Collection net with 13 Floatation buoys and 15 ft. of anchor line INCLUDED!



THE WATERSIDE GUARANTEE

Satisfaction Guaranteed or Your Money Promptly Refunded

If *within 14 days of receipt*, you are *not* satisfied with the WATER-WEEDER™ harvesting tool *for any reason*, simply return it shipped prepaid. Waterside Products Corp. will promptly refund your complete purchase price.

Limited Product Warranty

Waterside Products Corp., warrants to the original purchaser that each new WATER-WEEDER™ harvesting tool is free from defects in material and workmanship and agrees to repair or replace under this warranty any defective tool within one (1) year from original date of purchase.

Commercial Applications

The term of the limited product warranty is reduced to ninety (90) days if the WATER-WEEDER™ harvesting tool is used commercially.

Full details of this Limited Product Warranty appear in the owners manual.

Order Form

Call Toll Free or Write 1-800/552-1217

Name _____

Address _____

City _____ State _____ Zip _____

Qty.	Item	Each	Total
	Harvester	$299.99	
	Battery Pack	79.99	
	Adapter	7.99	
	4 ft. Extension	24.99	
		Amount of Order	
		N.Y. State Residents — add Sales Tax	
		Shipping and Handling (Add $10.00 for each Harvester and $8.00 for each Battery Pack)	
		TOTAL	

PAYMENT METHOD

☐ Check enclosed payable to:
Waterside Products Corp.

☐ MasterCard ☐ VISA

Card Account Number:

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Card Expiration Date _____ Customer Signature _____

Name of Bank Issuing Card: _____ Customer Phone # _____

or Call Toll Free
1/800-552-1217

In Canada call Collect 1/914-621-1155

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Payment by International Money Order or U.S. Funds
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Use your **VISA** or **MasterCard**

Waterside Products Corp.

P.O. Box 876, Lake Mahopac, New York 10541 USA

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108 Old Rt. 6
Lake Carmel, N.Y. 10512

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Spring/Summer

Treating lakes with alum: an overview

Bret Conover, Manager
Lake Management Services
General Chemical Corp.
Parsippany, NJ

Algae blooms, excessive vegetation and the odors and fish kills they cause plague lakes across the United States. In most cases, these problems are caused by dissolved nutrients from fertilizers, detergents and other sources of phosphate leaching.

A lake that has received waste-water for years may contain bottom muds so rich in organic matter that it becomes an ongoing source of phosphates. Even when the inflow of phosphate is eliminated, this nutrient remains in oversupply. Phosphates in sediment are released during summer when oxygen depletion in the lower layer of a lake allows them to redissolve.

Preventing problems caused by excessive nutrients is a twofold process: keeping nutrients out and eliminating the nutrients the lake already contains.

Federal and state laws restrict wastewater inflow to lakes from residences, agriculture and industry. But how to cleanse a lake of its nutrient content?

One proven method uses aluminum sulfate (alum), a nontoxic chemical applied in water and wastewater treatment plants to remove suspended solids and phosphates.

Alum is safe, effective and economical, and has been used for clarification of drinking water since the times of the ancient Romans and Egyptians. However, only in the past decade have lakes been treated with alum in North America and Europe, and only now is this method moving into the mainstream of lake treatment.

Alum works because it removes phosphates from the water column and seals in the phosphates contained in bottom mud. The lake bottom that lies within the cold deep layer of a thermally stratified lake is treated.

Most easily used in a liquid form, alum is either sprayed on the surface or injected underwater, in both cases from a boat or barge. Almost instantly, the alum forms a stable, relatively insoluble, gelatinous precipitate in the water that sweeps out suspended solids and removes dissolved phosphate as it sinks.

If enough alum is added, a thick precipitate layer will coat the bottom, sealing the sediments and inhibiting phosphate return to the water column. Laboratory and on-site tests determine the quantity of alum needed to form this protective coating.

To properly blanket the lake bottom, the vessel must make precise transits of the lake. In small lakes, shoreline markers guide the vessel. Large lakes demand more sophisticated means buoys or shore-based sonar, for example. The visible white precipitate that forms in the wake also aids navigation on calm days by marking the last path treated.

Alum treatment may take a few days or several weeks, depending on the size of the lake. The lake should be monitored for two years after treatment to determine the extent of phosphorus removal. Provided no further phosphorus enters the lake, alum treatment will control phosphate levels and eliminate algae blooms for many years.

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A DESCRIPTIVE SUMMARY OF THE

TYPE 2100 SEPTIC LEACHATE DETECTOR

WHAT IS THE TYPE 2100 SEPTIC LEACHATE DETECTOR?

This unique monitoring system was developed in response to a need for an economical means of locating areas of septic system and sewage effluent discharges entering streams, lakes, rivers, reservoirs and harbors. It is a portable field unit that can be operated continuously to scan expansive shorelines in a relatively short period of time. Real time feedback provides on-site determination of problem areas.

HOW DOES THE SYSTEM WORK?

The system monitors two parameters; fluorescence (organic channel) and conductivity (inorganic channel). This unique system is based on the theory that a stable ratio exists between fluorescence and conductivity in typical septic leachate outfalls. Readings for each channel appear visually on panel meters while information is recorded on a self-contained strip chart recorder. Recording modes include individual channel outputs or a combined output.

The submersible lift pump in the probe draws water from the bottom and passes it through the fluorometer unit which is sensitive to fluorescing organic molecules from laundry whiteners and septic wastes. The water then passes through a graphite electrode type conductivity cell sensitive to inorganic ionic components such as chloride (Cl^-) and sodium (Na^+). Fluorescence and conductivity signals are generated and sent on to an analog computer circuit that compares the signals against the background to which the instrument was calibrated. The resultant output is expressed as a percentage of the background and is continuously documented on the strip chart recorder. Full scale recorder output is provided for less than 1% septic leachate concentration. When higher than normal readings are encountered, discrete water samples can be taken directly from the instrument's discharge for later analysis of actual water quality. The system is powered by a standard 12 volt automobile battery or a portable generator. The system can be operated from a small boat moving at a walking pace along shorelines or in a fixed location for static monitoring applications. The entire system is completely portable.

WHAT ARE THE SYSTEM'S APPLICATIONS?

The system has a number of applications, which include:

- o assistance for regulatory agencies in monitoring the condition of shoreline septic systems and enforcing public health regulations
- o determination of the presence of septic leachate in potable or recreational waters
- o assistance in determining optimum lake levels and other facets of in-lake managment programs
- o help in planning future property development
- o identification of the direction and relative amplitude of groundwater inflows
- o monitoring of groundwater resources
- o monitoring downstream effects of municipal waste treatment outfalls
- o on-line monitoring of sewage effluent discharges

HOW DOES THIS METHOD COMPARE TO OTHER TECHNIQUES?

Conventional methods of leachate detection are primarily dye studies and in-depth water sampling programs. Simple visual observation is also used. All of these methods have their advantages as well as their disadvantages. The following matrix compares the characteristics of these methods with respect to accurate location of problem areas:

Technique	Survey Time Involved	Access Problems	Ease of Operation	Effectiveness	Total Cost
dye studies	extensive	yes	complex	good	high
water sampling	extensive	no	complex	fair	high
observation	minimal	no	simple	poor	low
TYPE 2100 SEPTIC LEACHATE DETECTOR	minimal	no	simple	excellent	low**

** The purchase cost of one complete Septic Leachate Detector unit is far less than the cost of a single leachate outfall survey done by most other techniques. The system's flexibility to meet a number of applications and its continued use as a periodic check on existing conditions allows long term amortization which further reduces overall cost

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clivus™

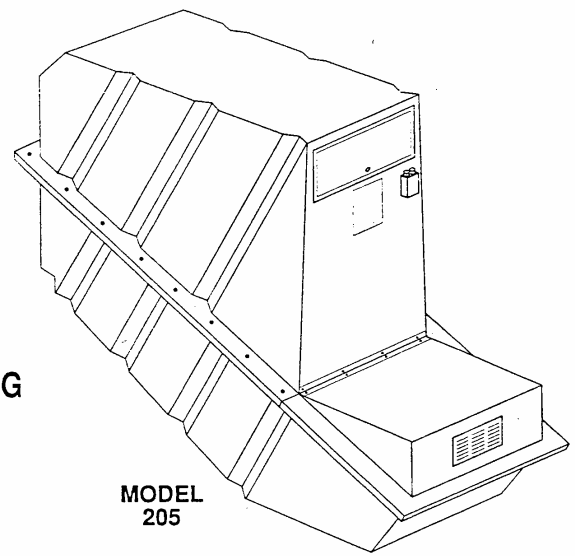
Solutions Through Recycling Technology

MULTRUM™

MODEL 205

ON-SITE HUMAN WASTE RECYCLING SYSTEM

- COST-SAVING
- EASY TO INSTALL
- EASY TO MAINTAIN
- NATURAL COMPOSTING PROCESS



MODEL 205

Warranty
Limited warranty of 5 years on all components is provided with every unit, except the pump and fan which have a limited one-year warranty, the solar panel which is warranted by the manufacturer, and the fire protection system which has a limited 3-year warranty by the manufacturer.

Specifications are subject to change without notice.

Note: The Clivus Multrum system conforms to all requirements of the National Sanitation Foundation (NSF Standard No. 41) for Wastewater Recycle-Reuse Water Conservation Systems.

Carefully engineered and patented composting tank. U.S. PATENT NO. 4084269
Liquid Respray Assembly - U.S. Patent Pending.

The multrum is made of cross-link, high-density, vandal resistant polyethylene and conforms to standard toilet stall specifications and standard building and basement dimensions.

The Model 205 multrum is designed for up to 150 uses per day with a maximum usage of 36,000 per year.

Check the specifications on the reverse side and you'll see why the waterless on-site human waste recycling system that's revolutionizing public restrooms across the country will save you a lot more than just water!

Clivus Multrum, Inc., has been providing public facility officials, homeowners, and private industry with solutions to human waste management problems for years with our National Sanitation Foundation-approved recycling systems. Our commitment to producing high quality products and to meeting the needs of our customers has made us the leader in the on-site human waste technology industry.

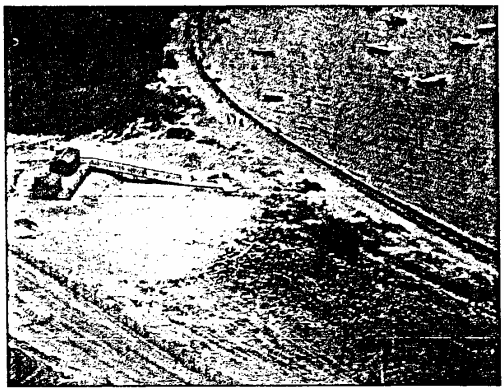
This dedication to excellence is evidenced by the over 1,000 Clivus public facility installations in the U.S. alone. Among our public facility customers are the Armed Services, highway agencies, national, state, county, and city park departments, and the Girl Scout organization.

Girl Scout International Conference Center, Briarcliffe Manor, New York. Typical bathroom with Clivus system located in all buildings.

THE RECYCLING SYSTEM

The Clivus is a cost-effective, low maintenance, on-site, organic waste recycling system that uses natural biological decomposition to convert toilet wastes into small amounts of stabilized, safe, and usable end products. The system operates without water or chemicals and uses practically no energy. It produces no odor and is environmentally safe.

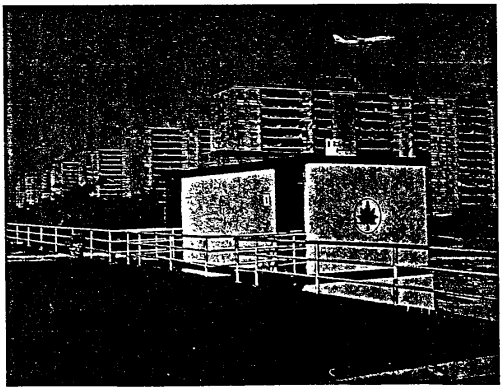
In addition, Clivus Multrum offers its experience in designing greywater treatment systems that use highly efficient leaching lines, evaporation, or evapotranspiration methods. Clivus can assist in planning greywater systems to complement the installation of our human waste recycling systems. Solar powered electrical systems are also part of the Clivus product line. Photovoltaics are used to harness the sun's energy to power fans, pumps, and lights. Complete packages including buildings with recycling systems can be provided.



Hart Miller Island, Chesapeake Bay, Maryland. Island location and poor soil conditions prevented other types of restroom facilities. Clivus was the solution.

SITE-SENSITIVE

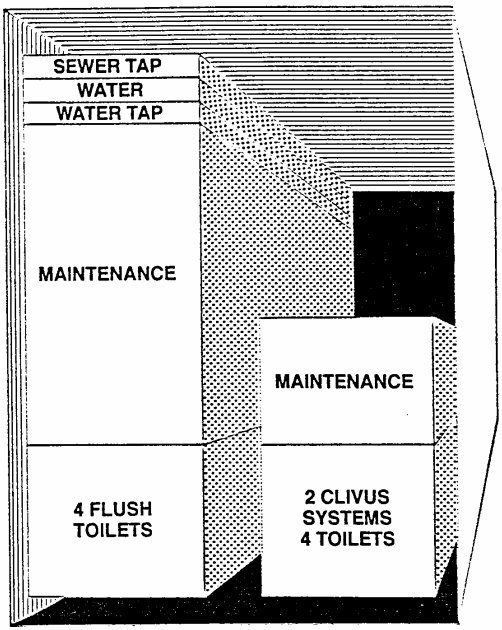
High seasonal volume, extreme temperatures, inadequate soil, remote location, or high vandalism incidence — none of these potential problems hampers the effectiveness of Clivus recycling systems. Where other systems fail or are unfeasible, waterless recycling systems are the solution.



77th Street, New York City. Just one of the network of New York City Parks Clivus installations.

COST-EFFECTIVE

Public facility personnel across the country find Clivus to be highly cost-effective. The system operates more efficiently, more effectively, and at a lower project cost than any other kind of waste treatment system. The Clivus recycling system can be installed at a fraction of the cost of a conventional water and sewer hook-up. The minimal maintenance with a Clivus further reduces operating costs.

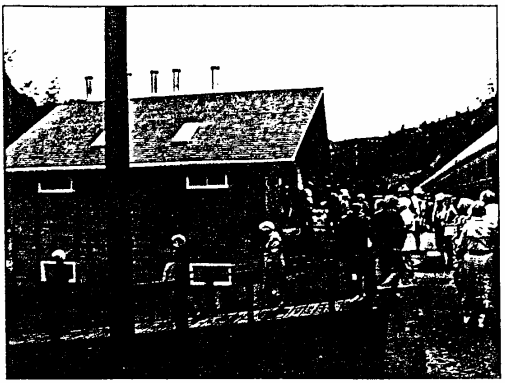


Ten year cost comparison based on equally priced facilities. Chart does not include costs of running sewer lines or operating heating systems for flush facilities. Note: Clivus systems can function year-round; flush facilities often allow for only 27 percent annual utilization.

CUSTOMER SERVICE

Clivus Multrum offers comprehensive planning, installation, and monitoring services to ensure optimum performance of every system installed. Product warranties are provided with certification.

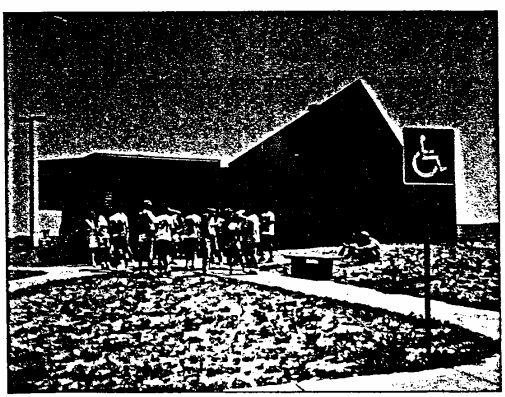
The Clivus product line covers a wide range of applications where traditional methods of sewage disposal are impractical, prohibitively expensive, or logistically impossible. Each product is backed by the Clivus Multrum standard of excellence.



Algoma Central Railway, Agawa Canyon Park, Ontario. A high seasonal use restroom facility with Clivus recycling systems and a Clivus-designed grey-water system handles the 1,000 daily uses from May through mid-October.

ENVIRONMENTALLY SOUND

The Clivus waste recycling system is environmentally safe. The small amount of compost that is annually removed from the system is biologically stable, odor free, and similar to top soil in bacterial composition. Because liquid and solid wastes are thoroughly decomposed within the system, groundwater quality is preserved. By treating waste at the point of origin, the Clivus system also eliminates the need for costly central waste treatment facilities or septic systems.



Wyoming Highway Department, Mule Creek Junction Rest Area. Clivus recycling systems accommodate this high traffic area on Highway 85.

HOW IT WORKS

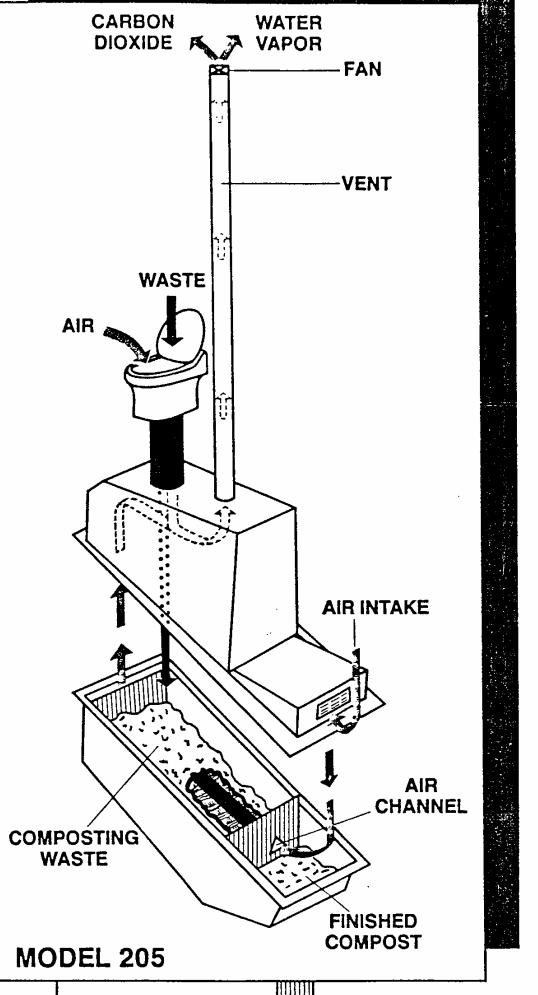
The Recycling System

A single polyethylene recycling tank can accommodate two to four toilets and urinals (depending on model), approximately 36,000 uses per year.

Human waste from the toilets and urinals is retained in the recycling tank, along with additions of carbon-rich bulking agents such as planer shavings or coarse sawdust. The organic carbon contained in the solid waste and the bulking agent, along with the nitrogen supplied by the urea, sustain and promote the growth of colonies of aerobic bacteria. These in turn decompose the waste products into odorless, non-hazardous water vapor, carbon dioxide, and a small amount of safe compost and nutrient-rich liquid as end products. The composting process gradually reduces the volume of human waste solids by 95 percent, at which time the stable compost is removed from the tank and may be used as soil conditioner.

Baffles and air channels in the recycling tank control air flow, assuring an oxygen-rich environment and accelerating natural decomposition. A fan in the vent cap draws air continuously to keep the toilet stalls odor-free. The fan requires 12 volt DC electricity and can be powered by a photovoltaic system where AC power is not available. Facility personnel can easily maintain the system.

The Clivus Multrum Recycling System has been approved by the National Sanitation Foundation.



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clivus™ Solutions Through Waste Technology

The hard copy of this report includes a large map showing the Watershed Land Use and the another map showing soils and highly erodible land in the Beaver Creek Reservoir area. These maps are not available in this electronic version of the report.